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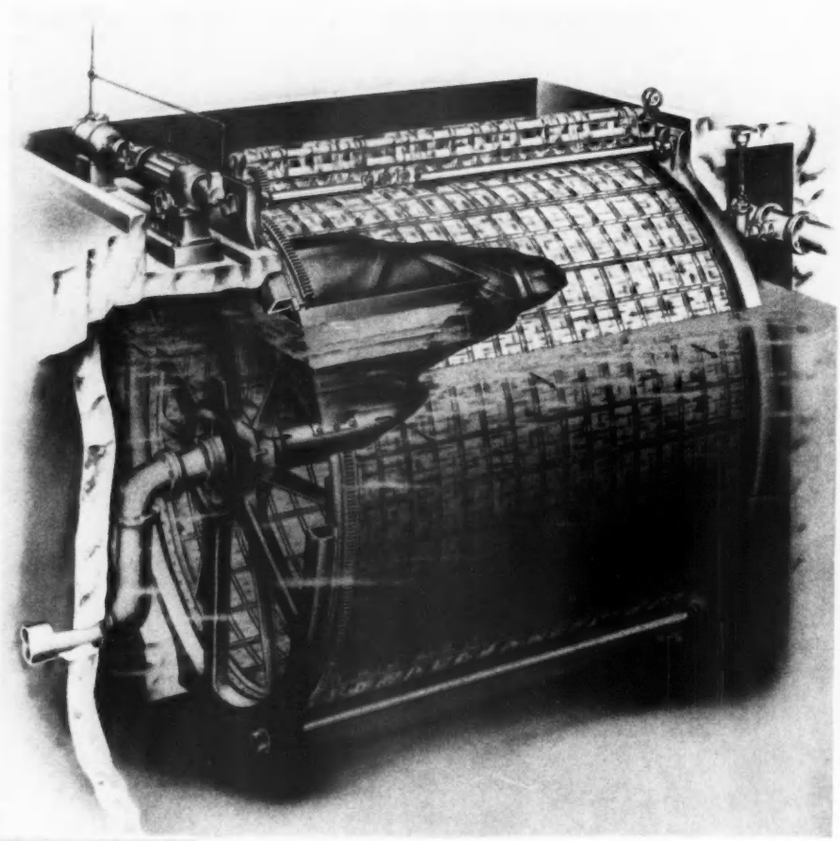

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Established 1856

No. 5356 **SEPTEMBER 19, 1958** VOL. 206

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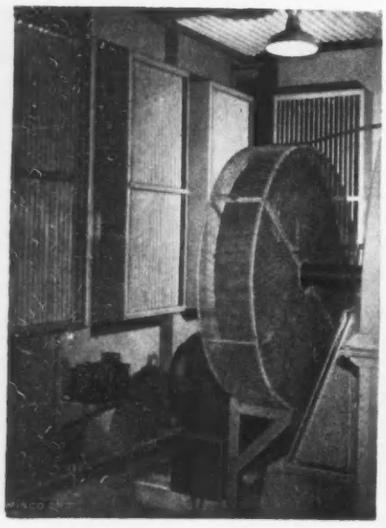
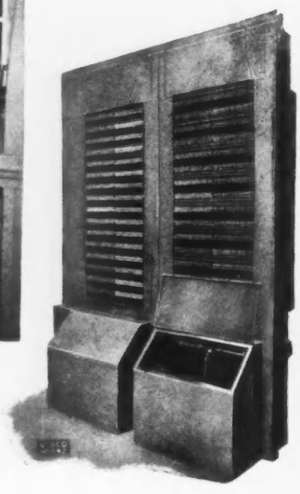


Left: Cleaned air side of "Visco" "Reciprojet" Air Filter at Abbey Works of The Steel Company of Wales Ltd.



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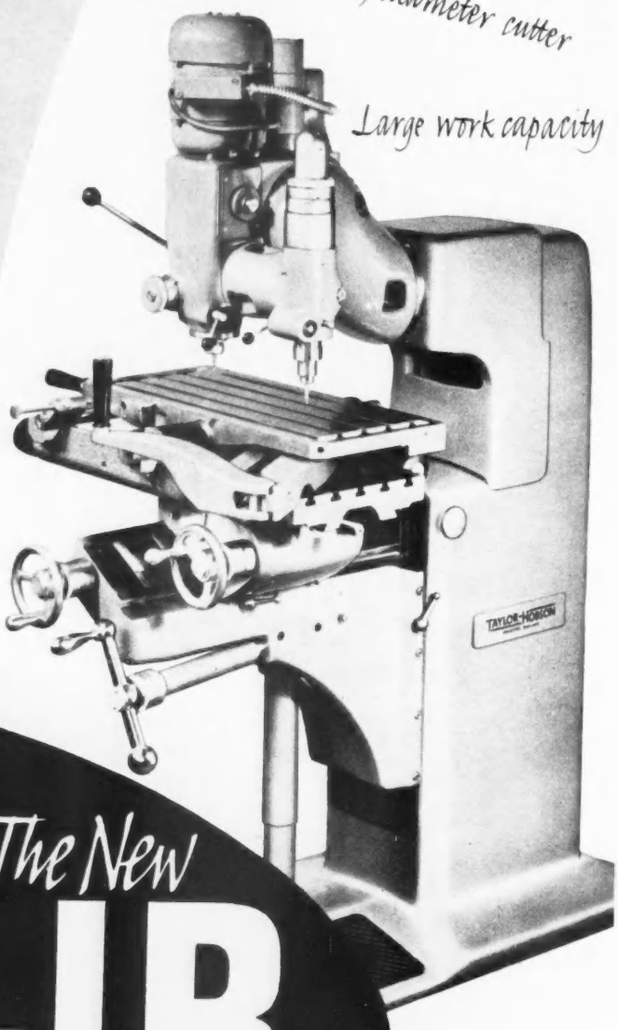

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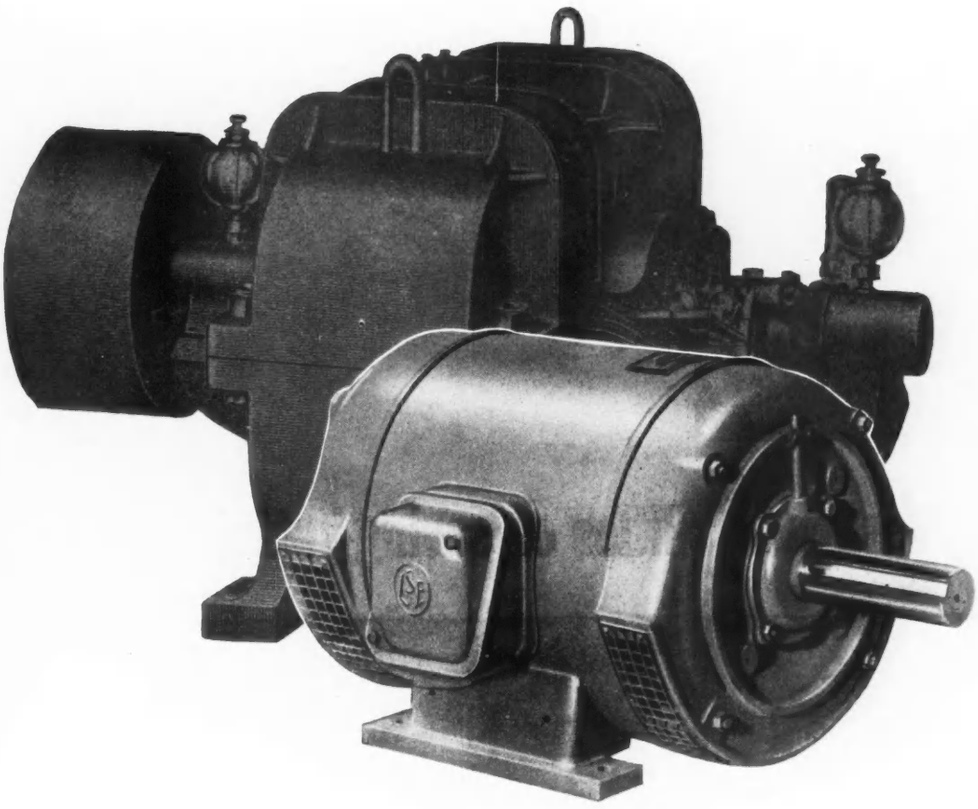

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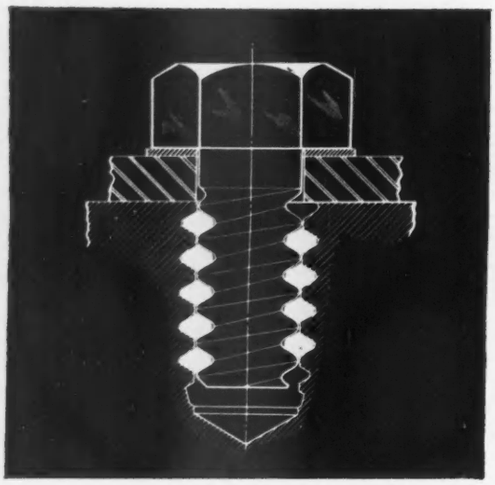

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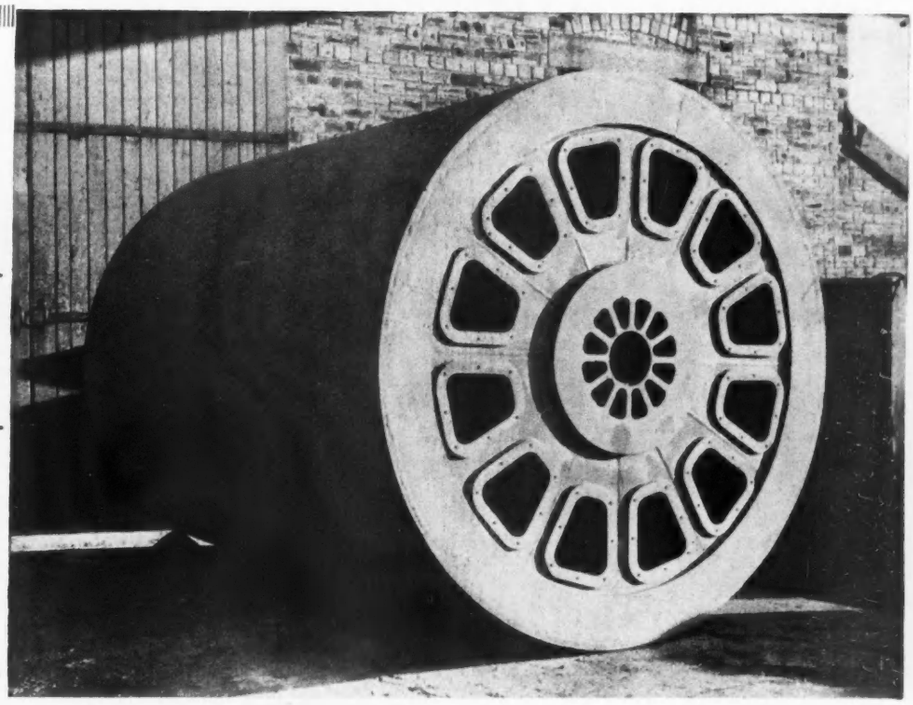

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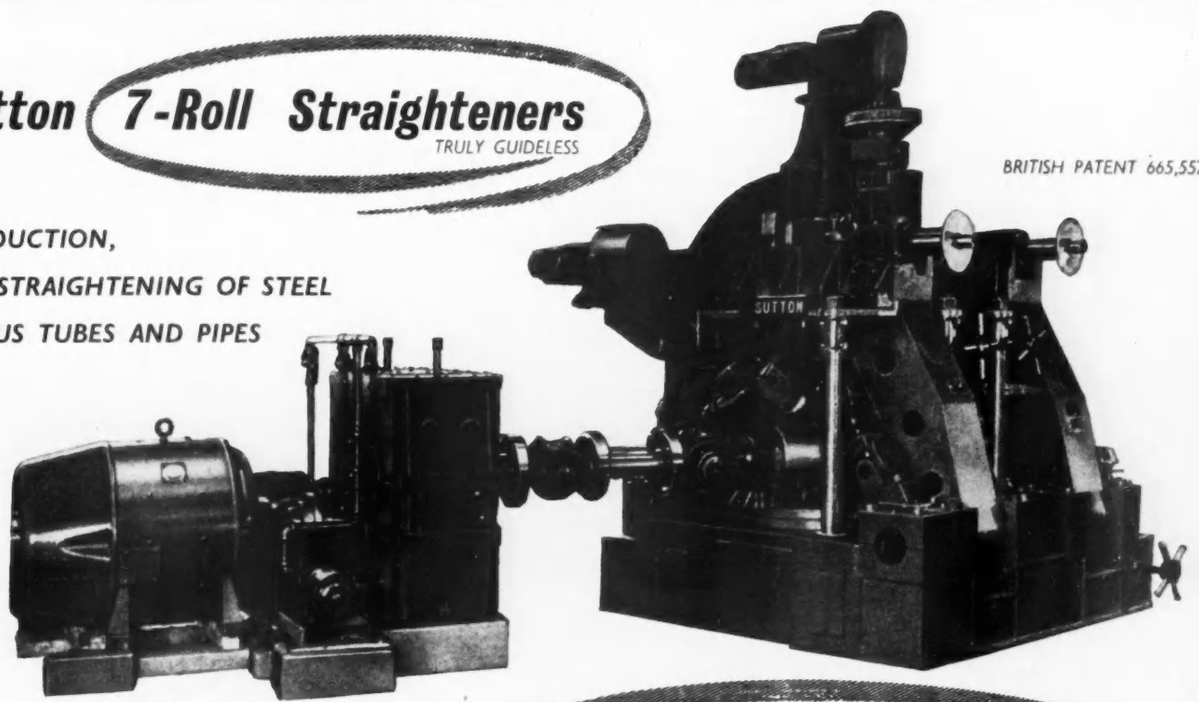

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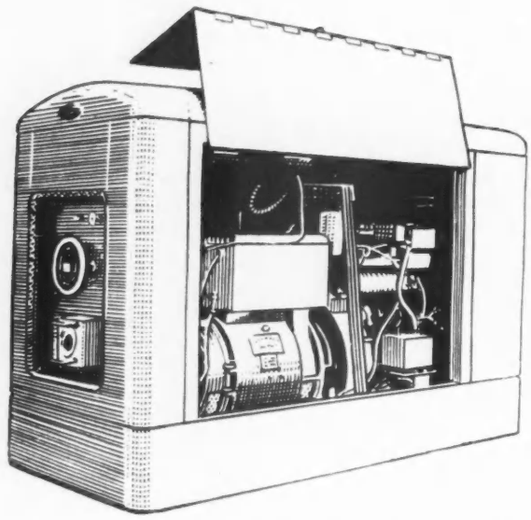

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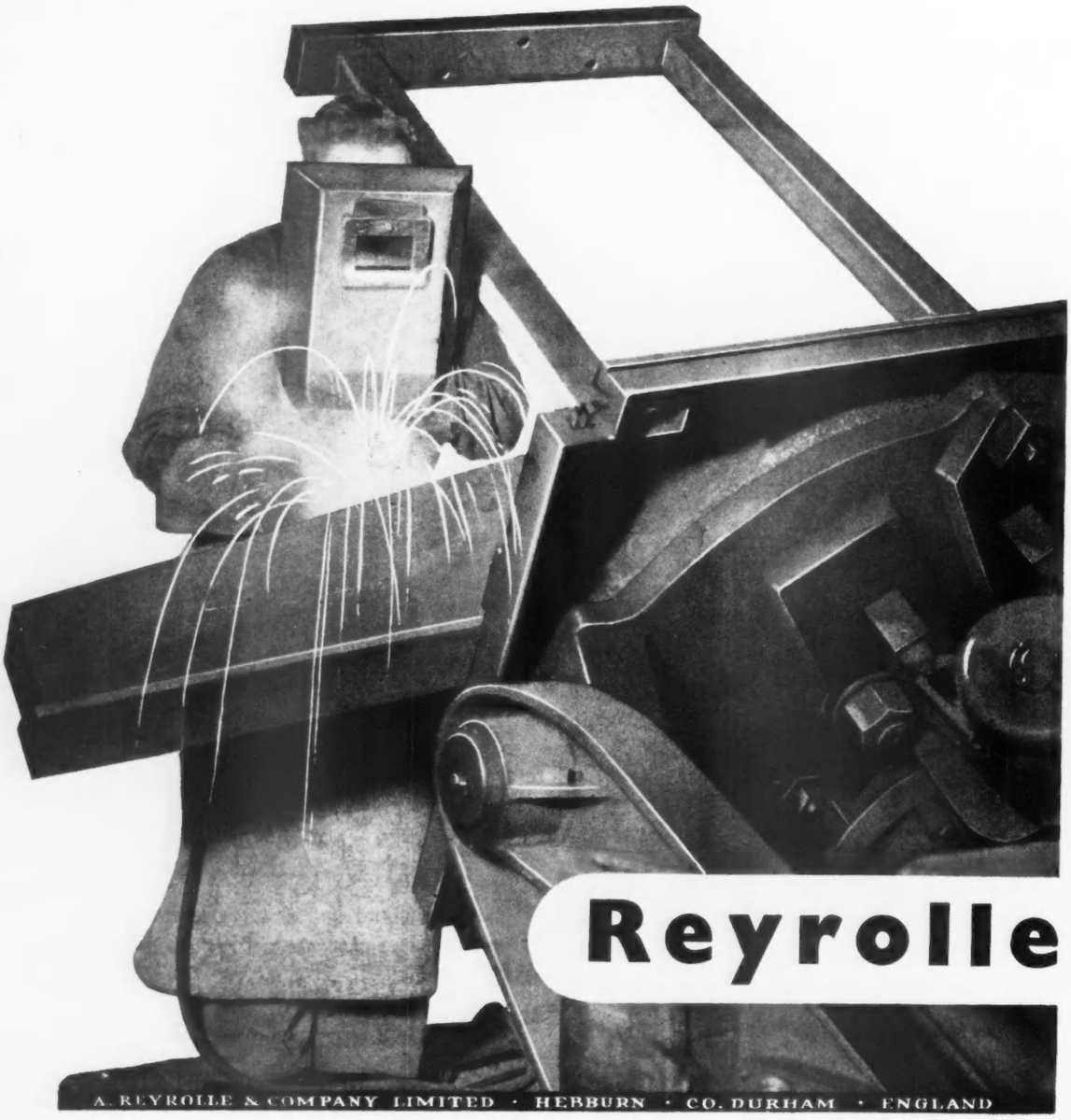

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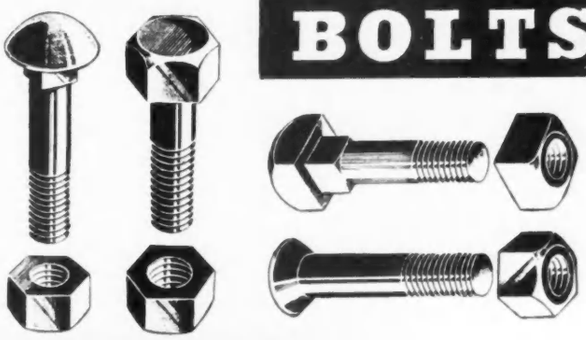

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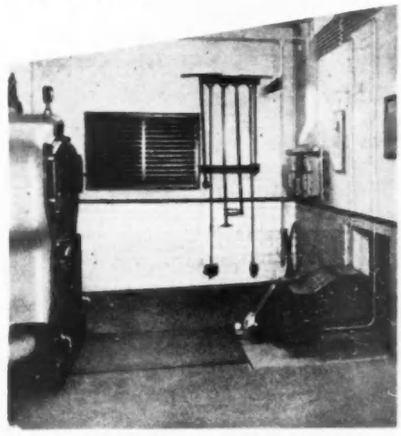

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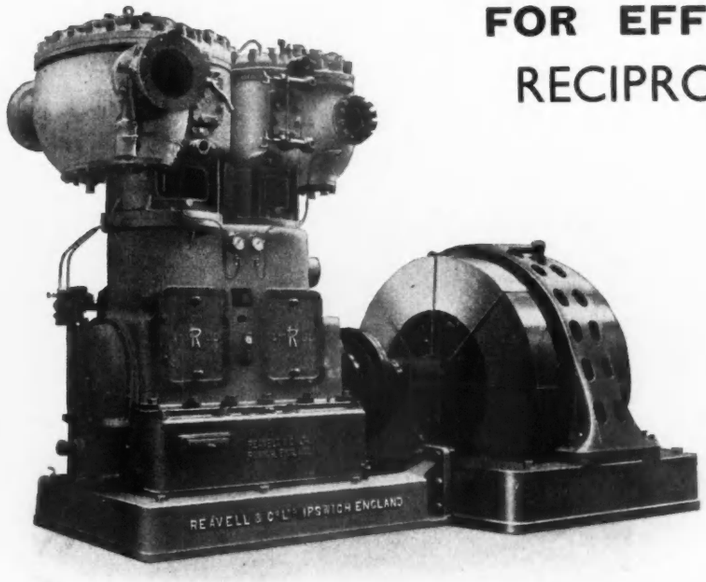

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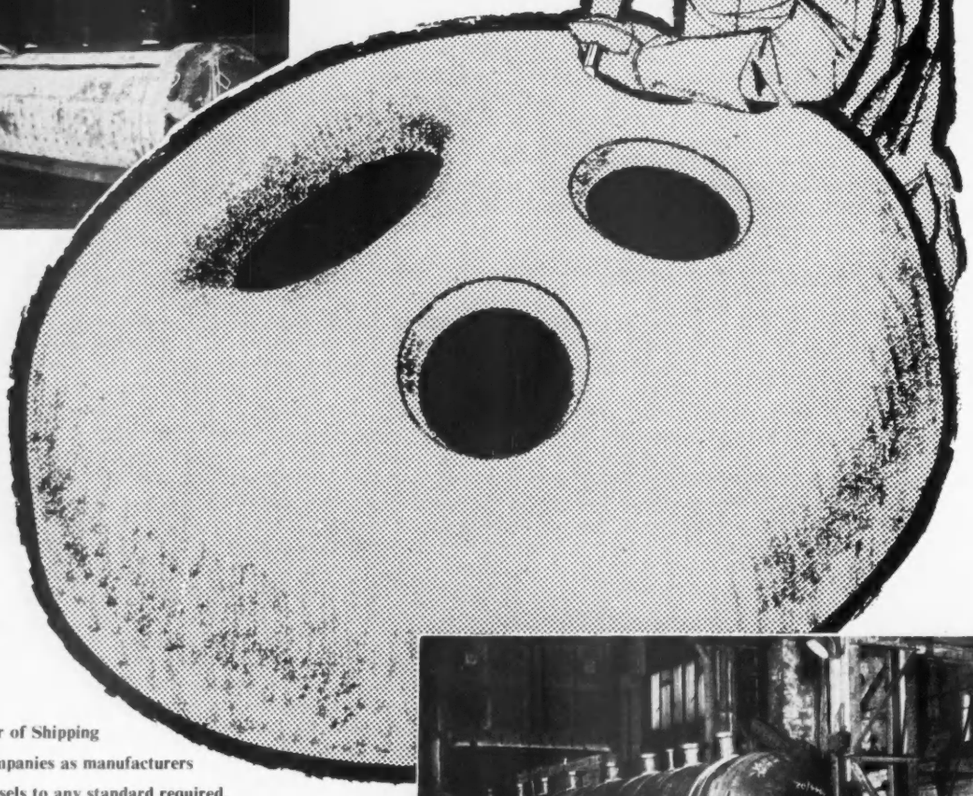

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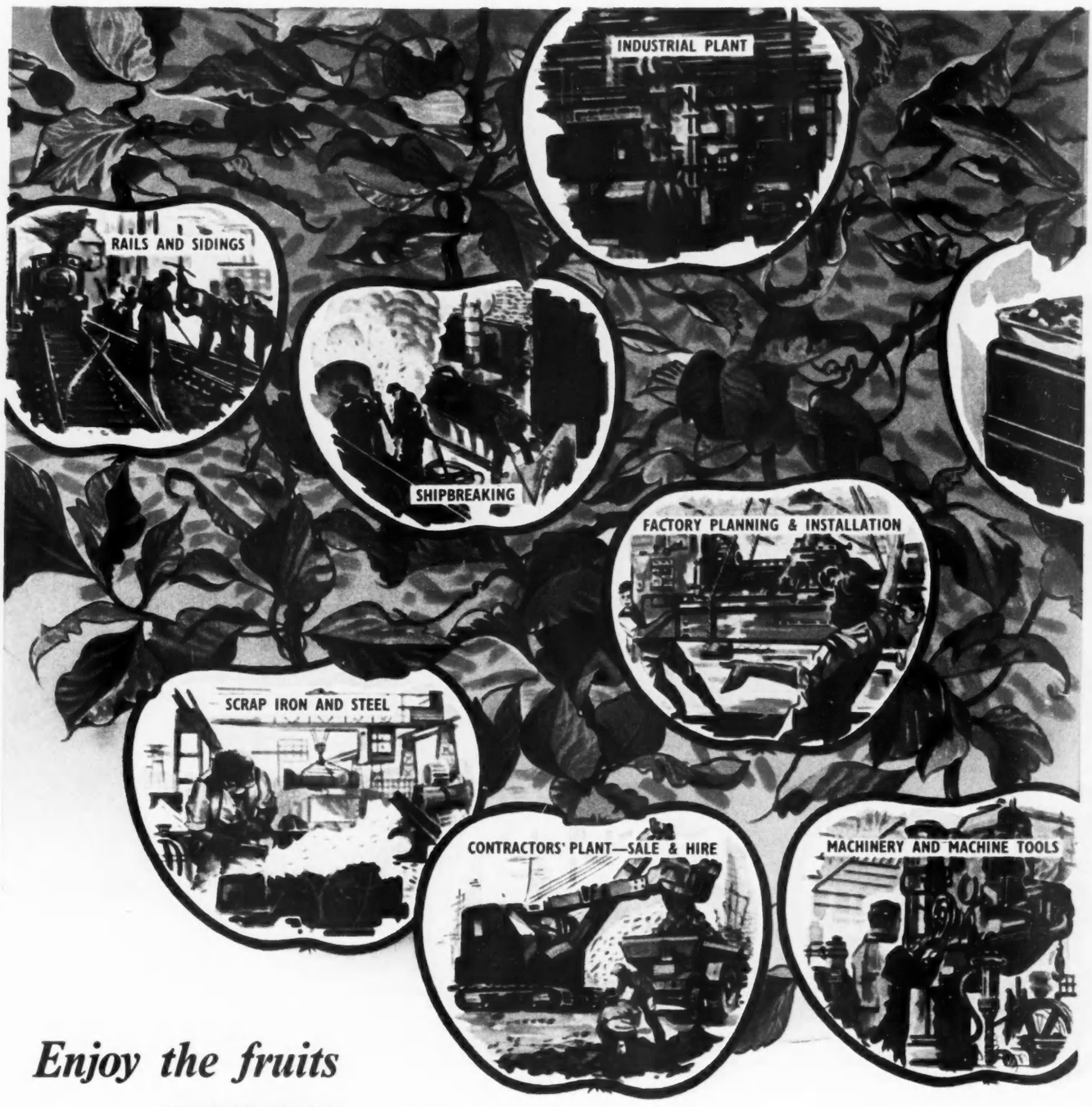

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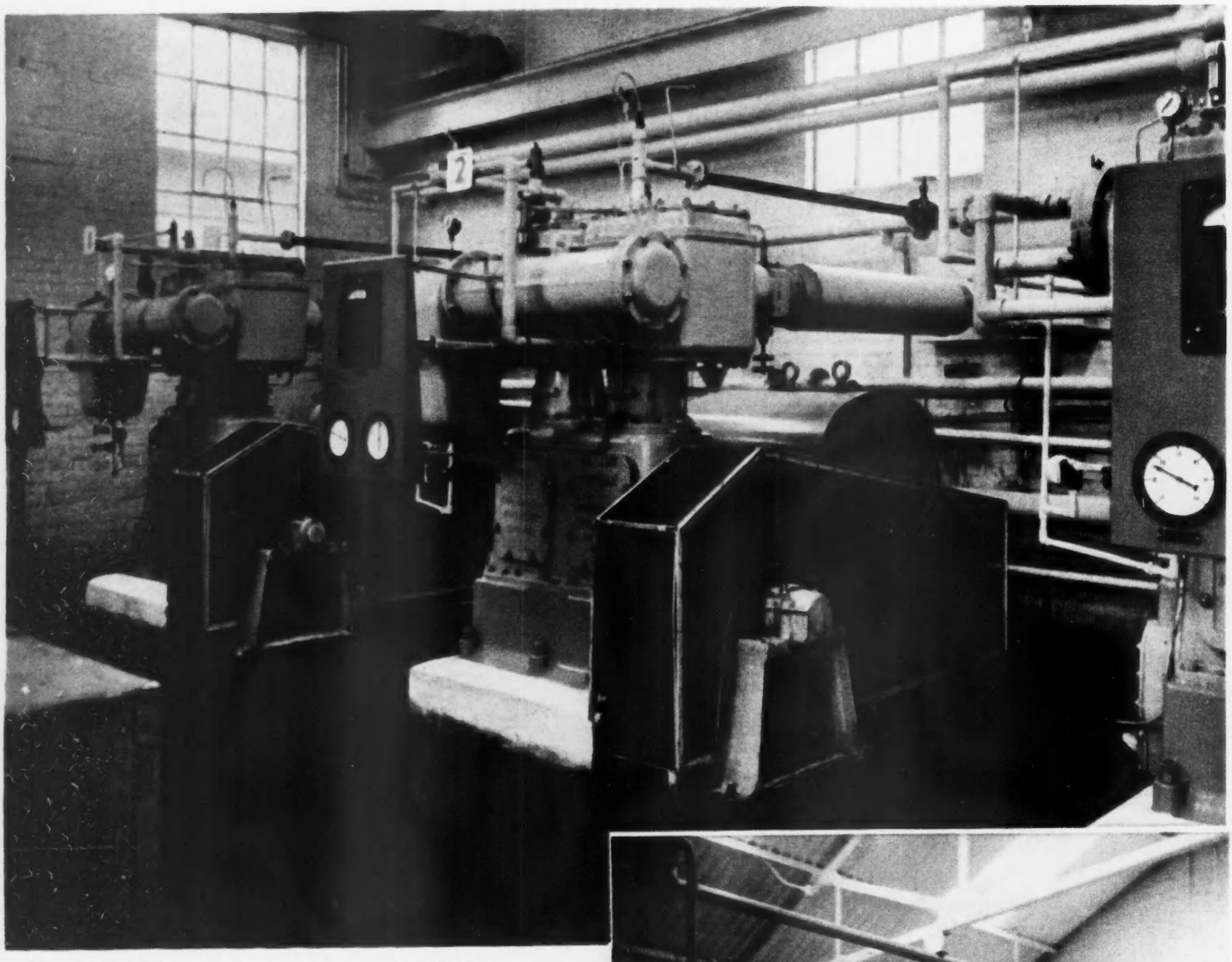

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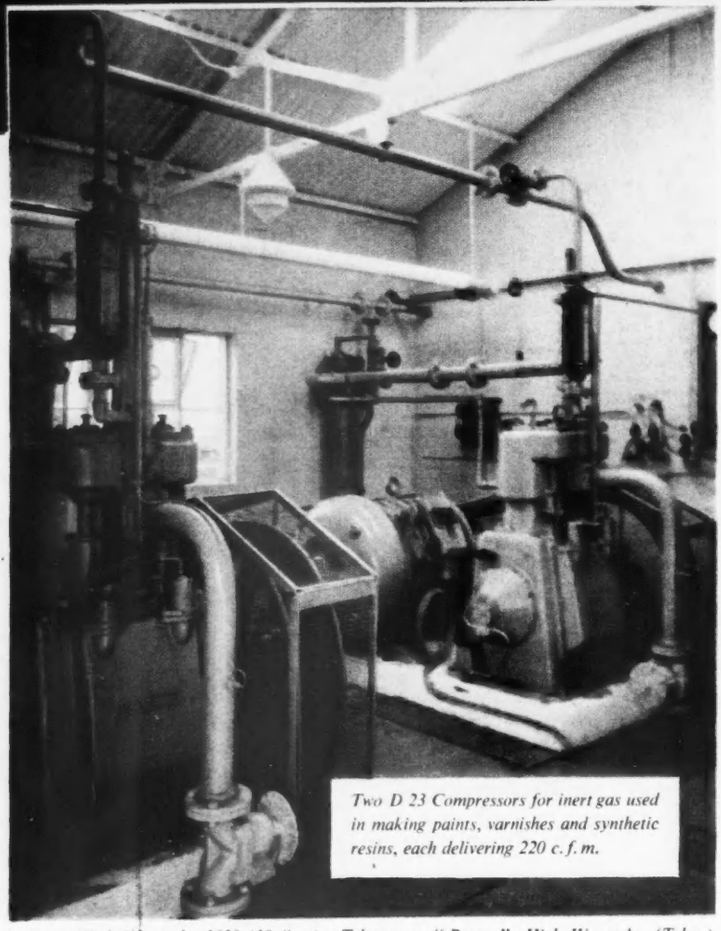

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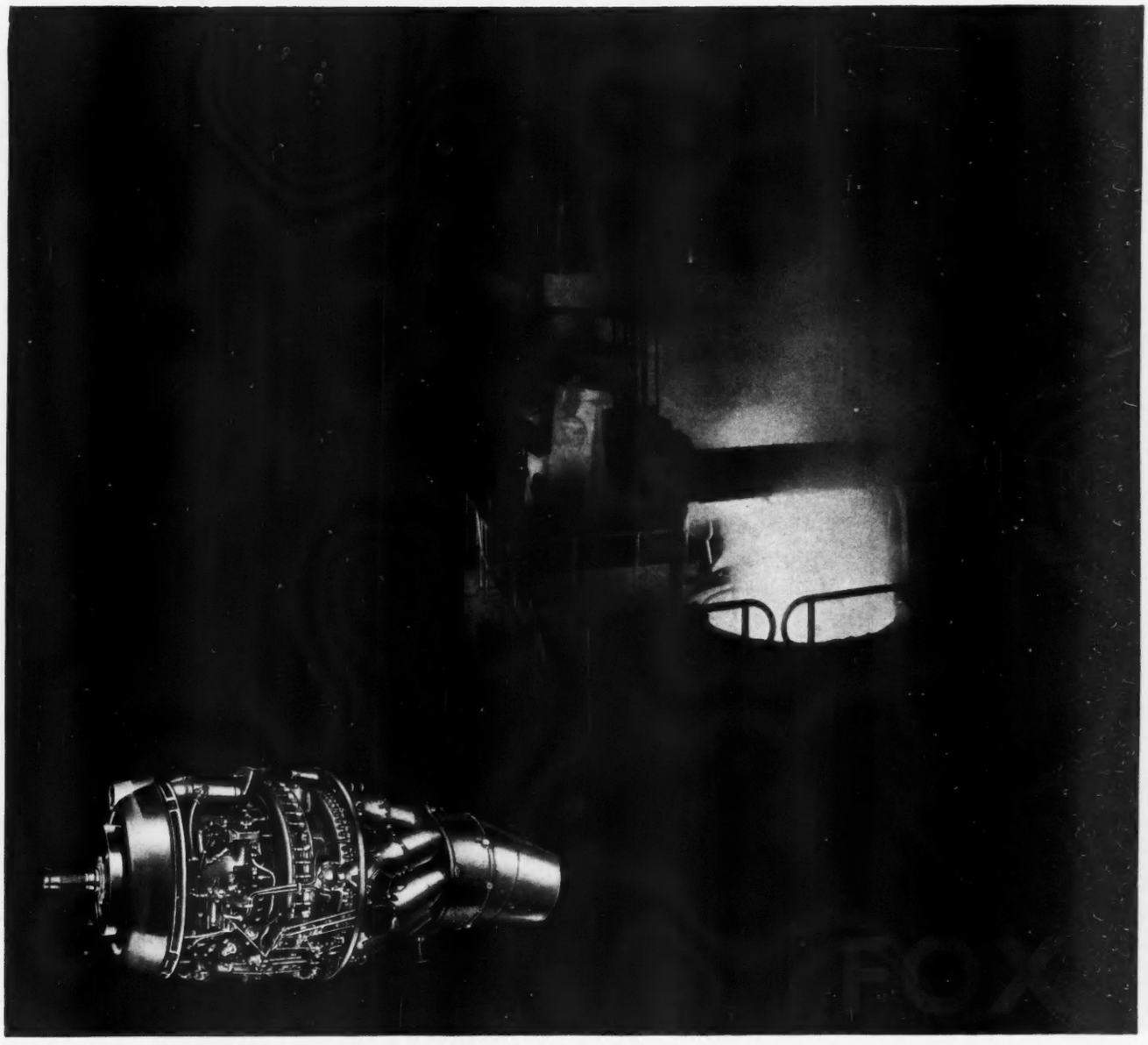

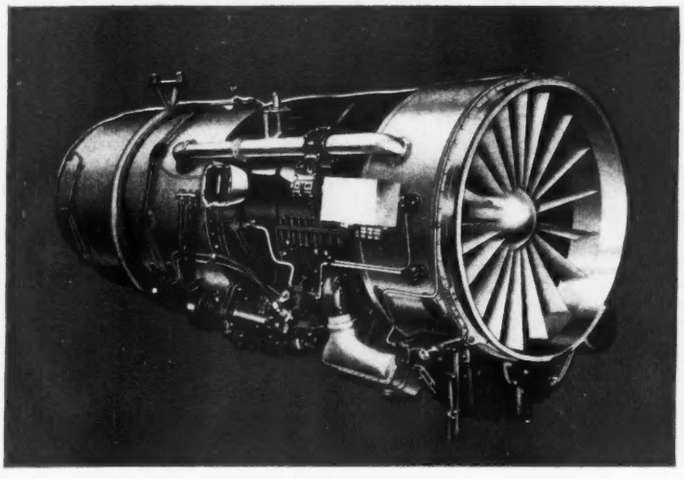

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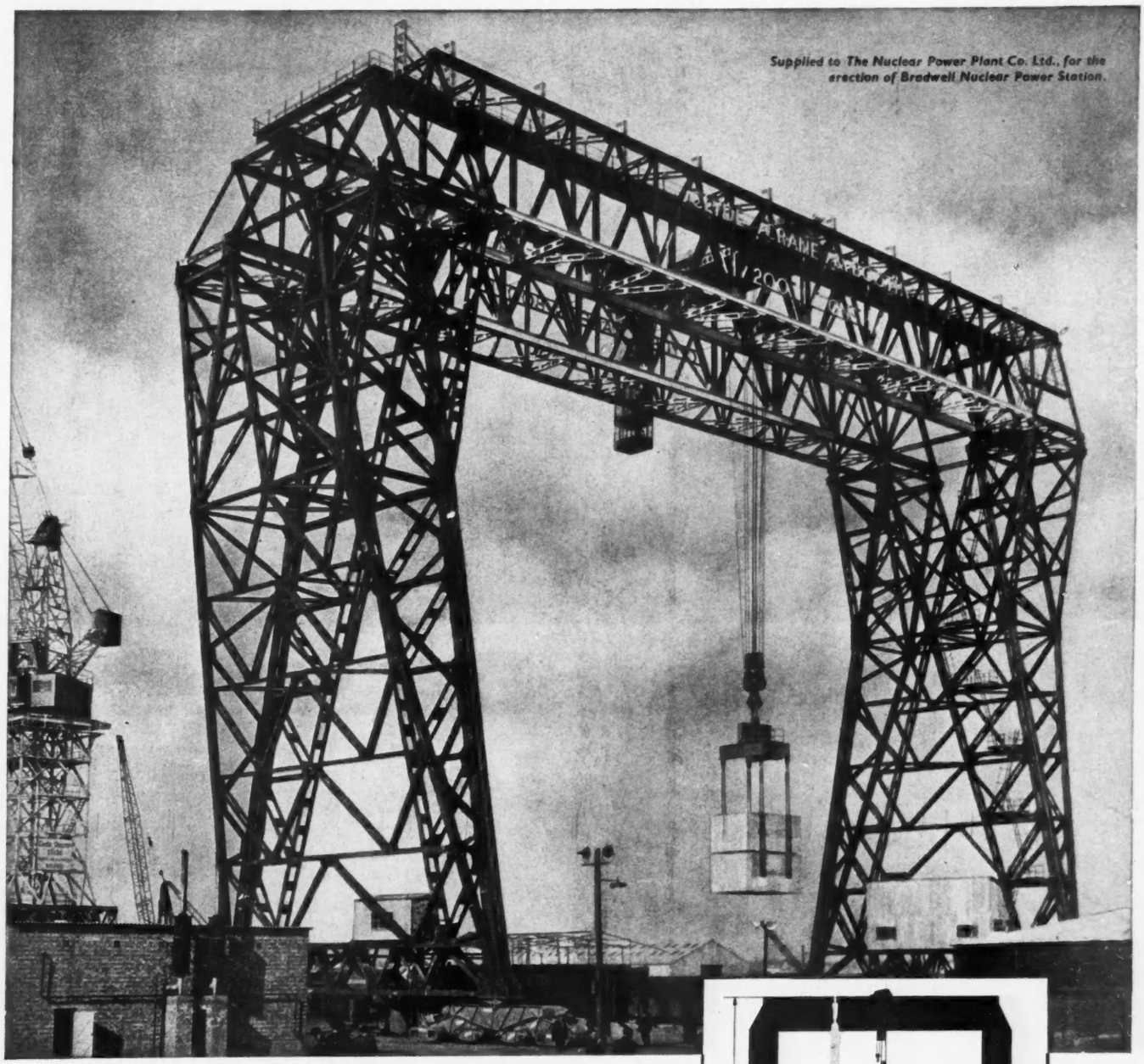

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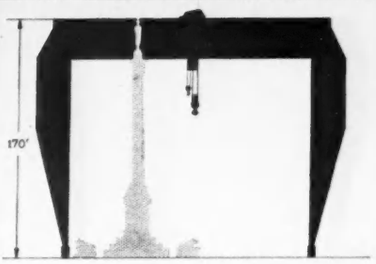

The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

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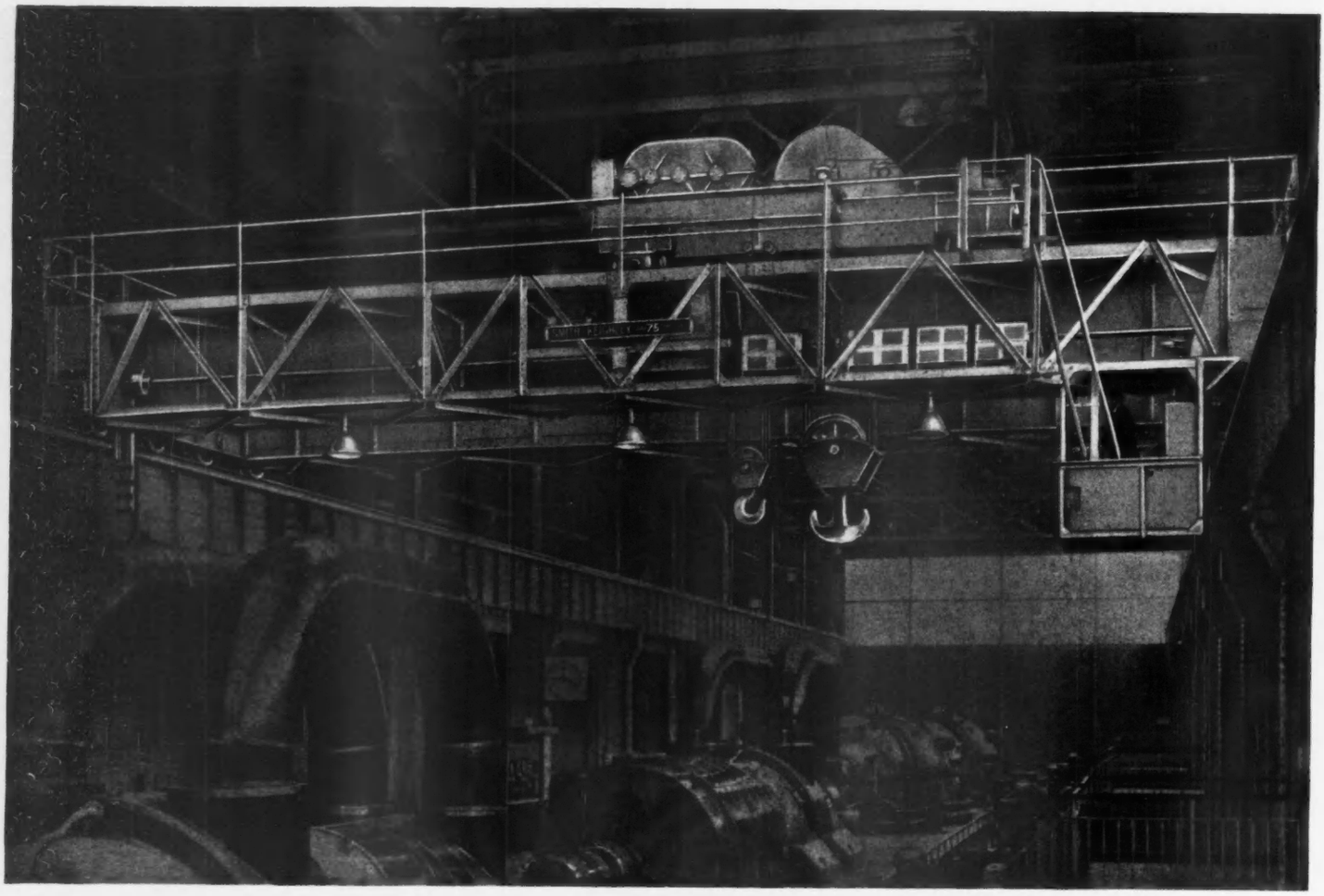

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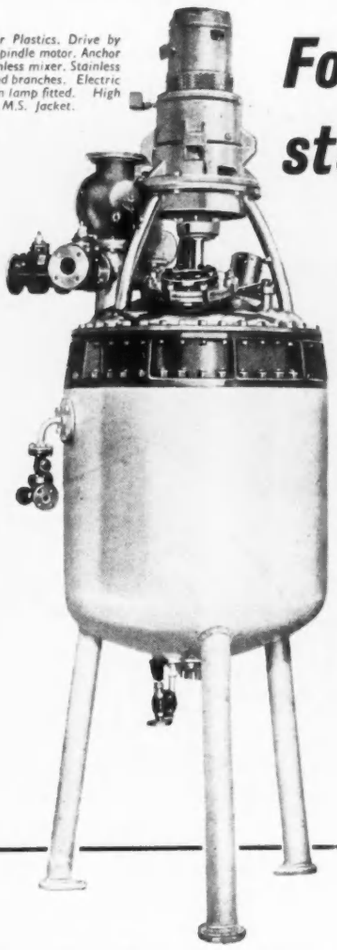

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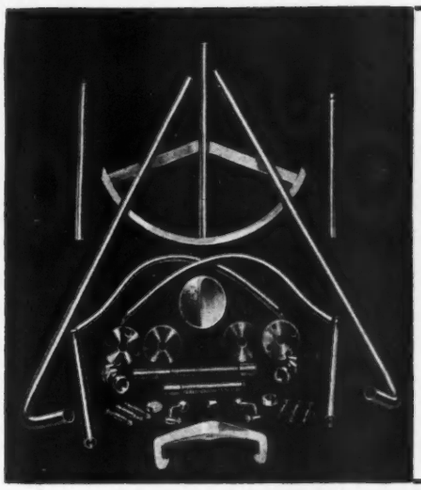

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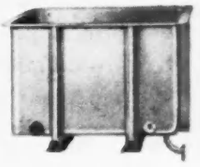

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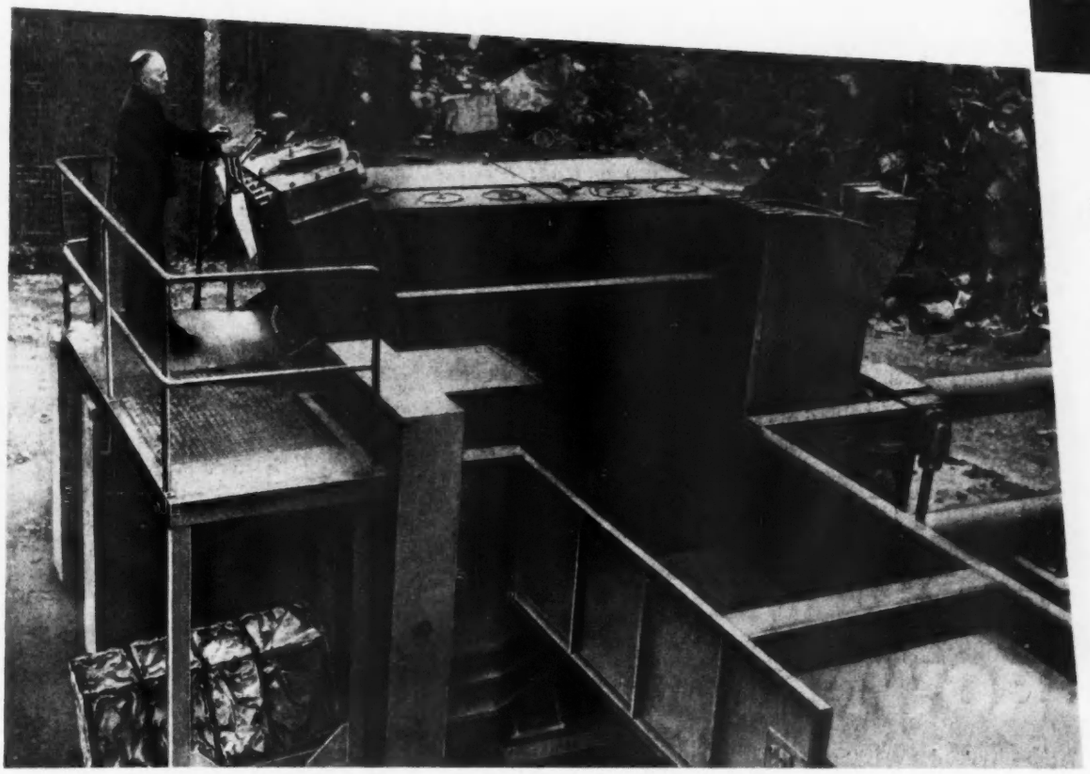

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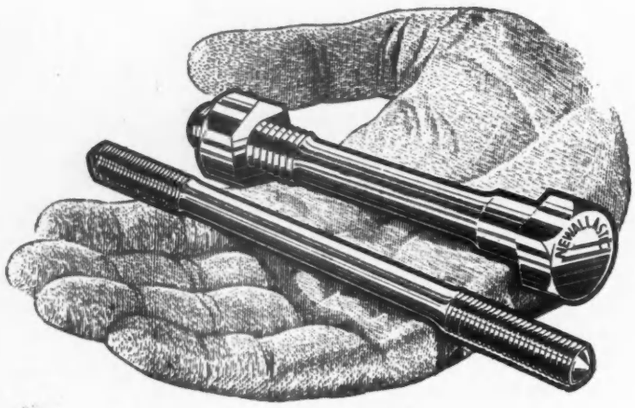

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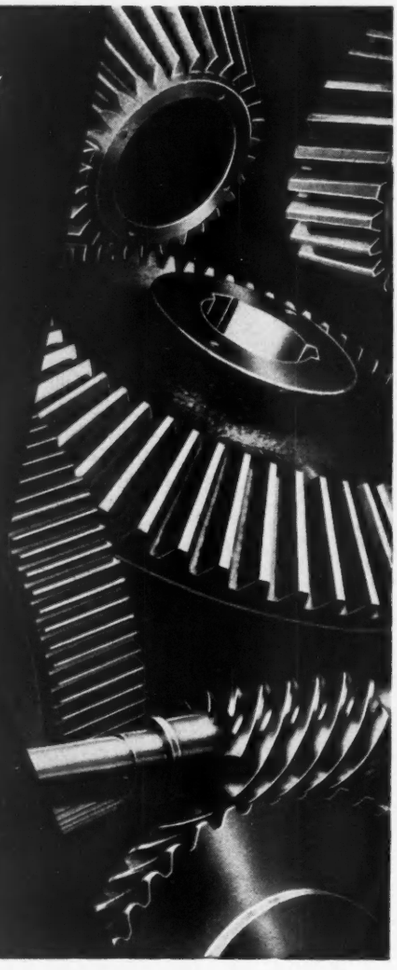

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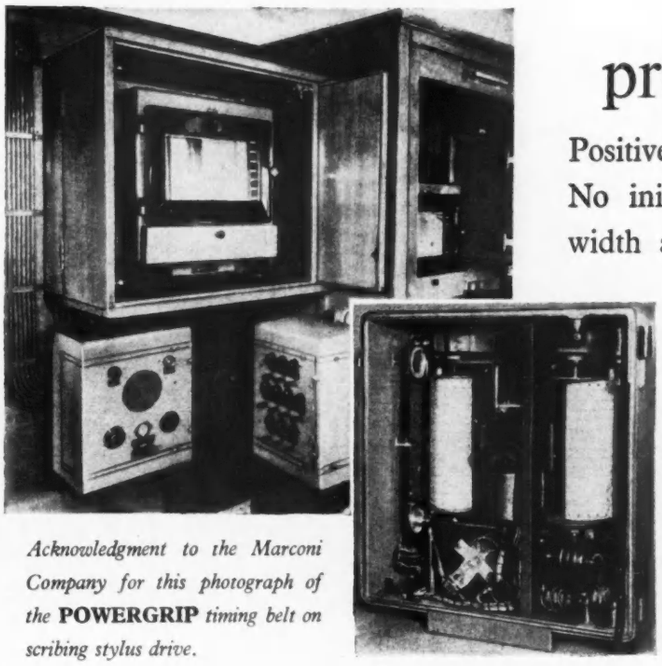

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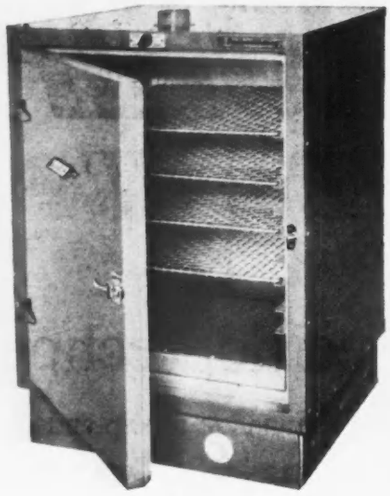

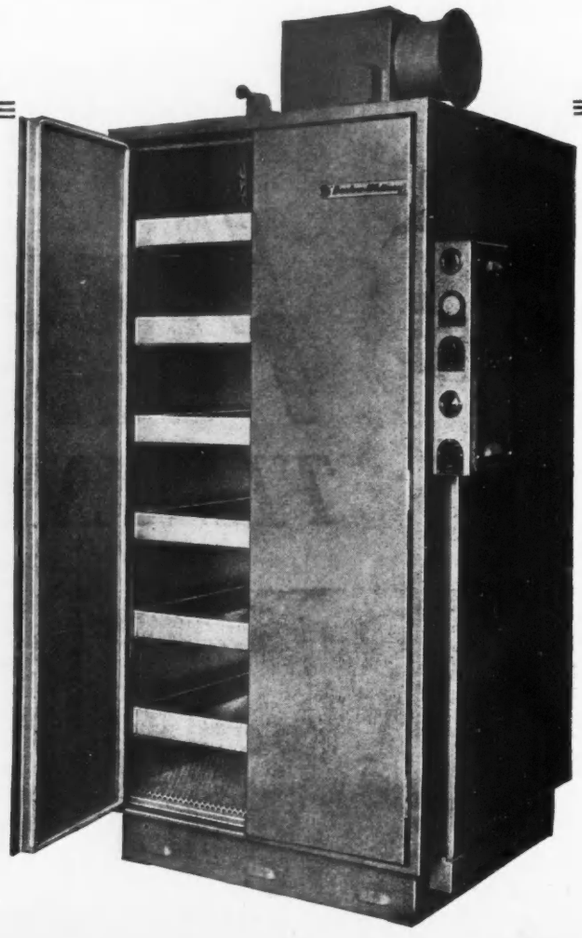

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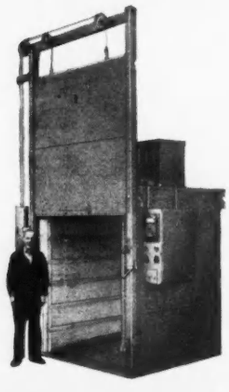

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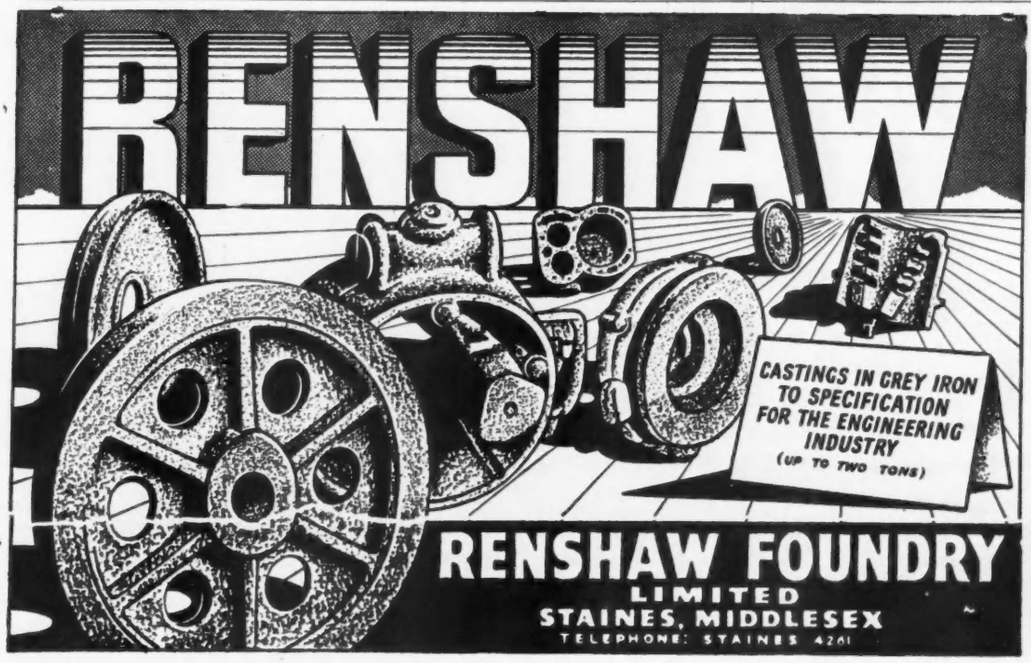

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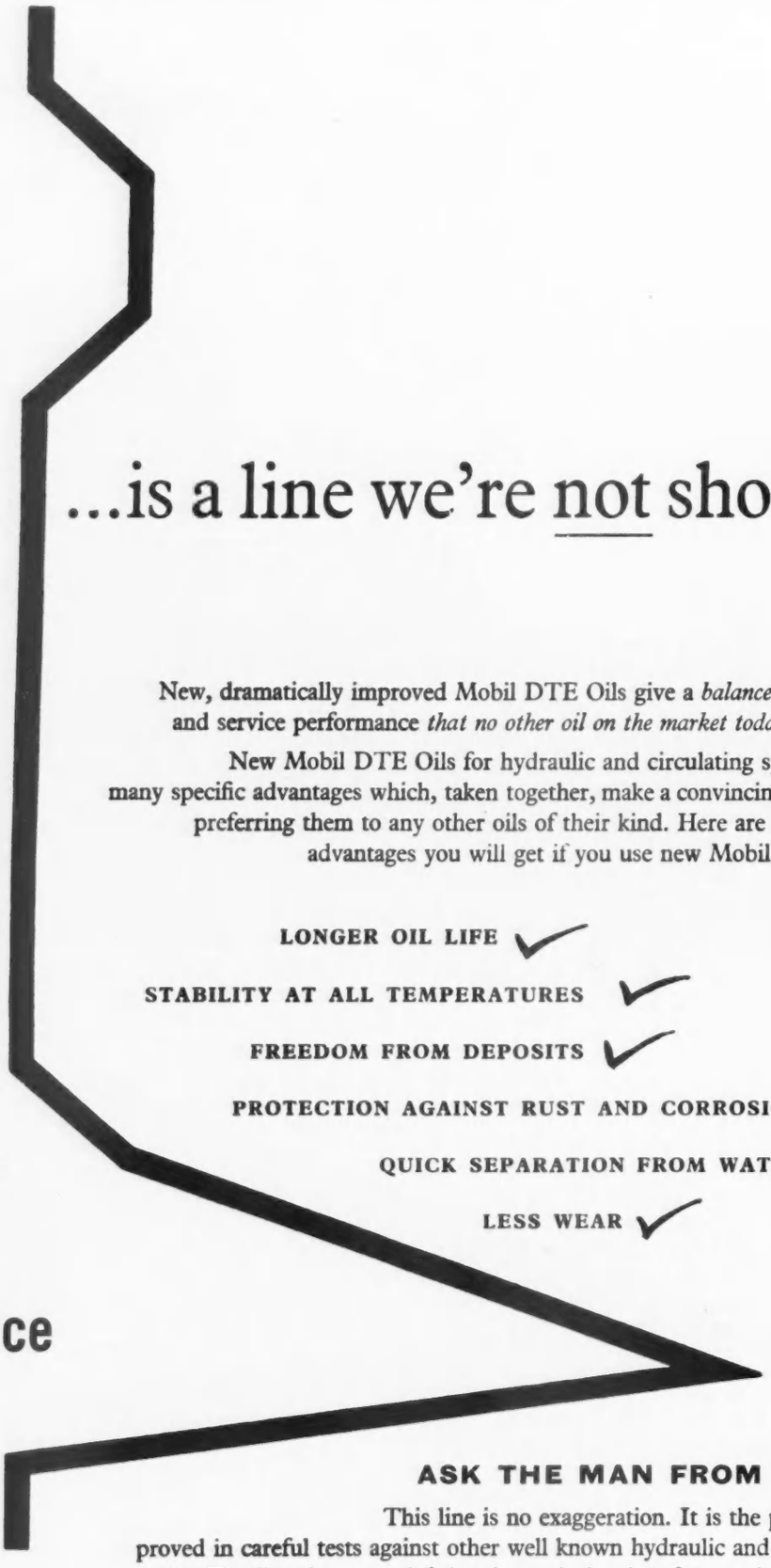

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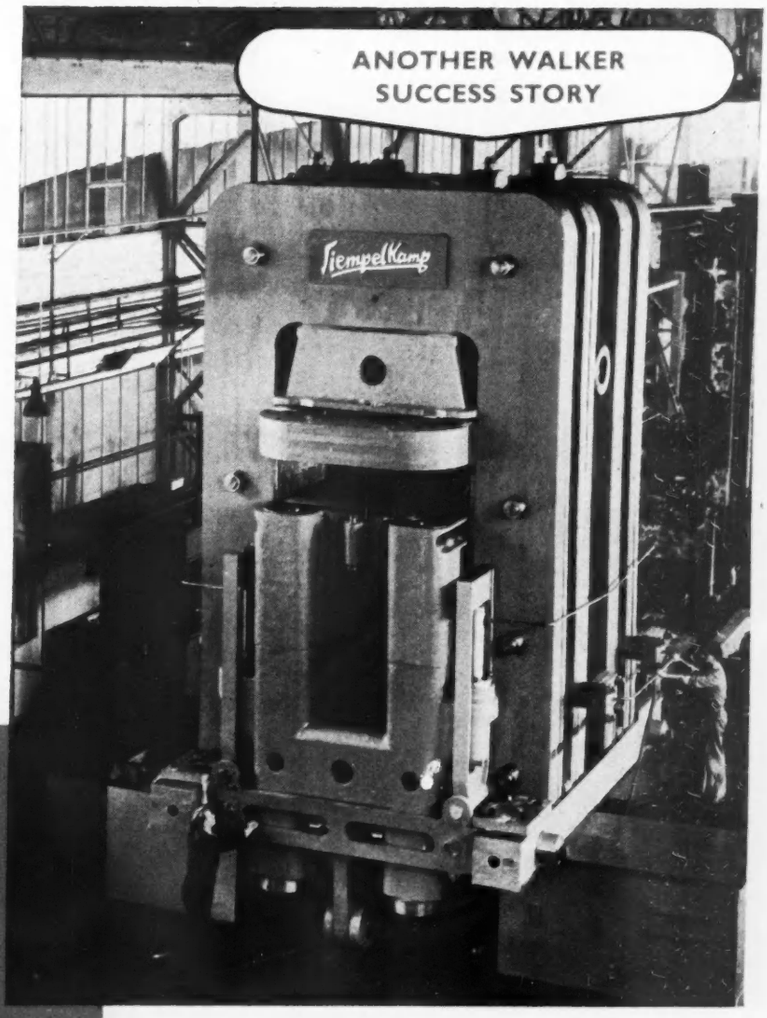

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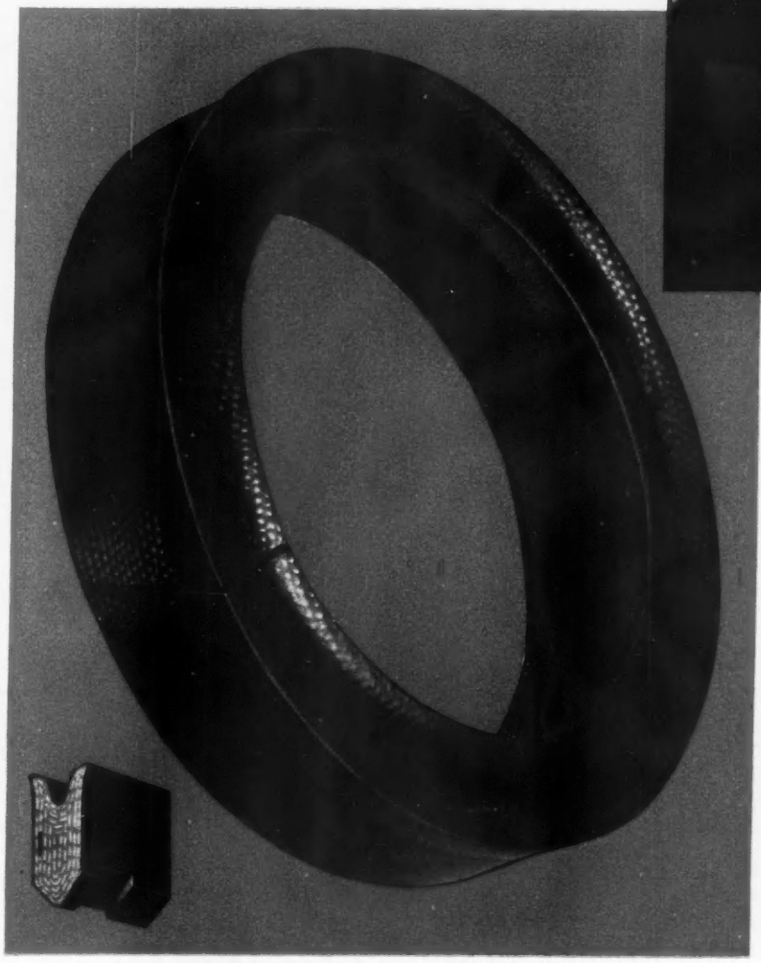

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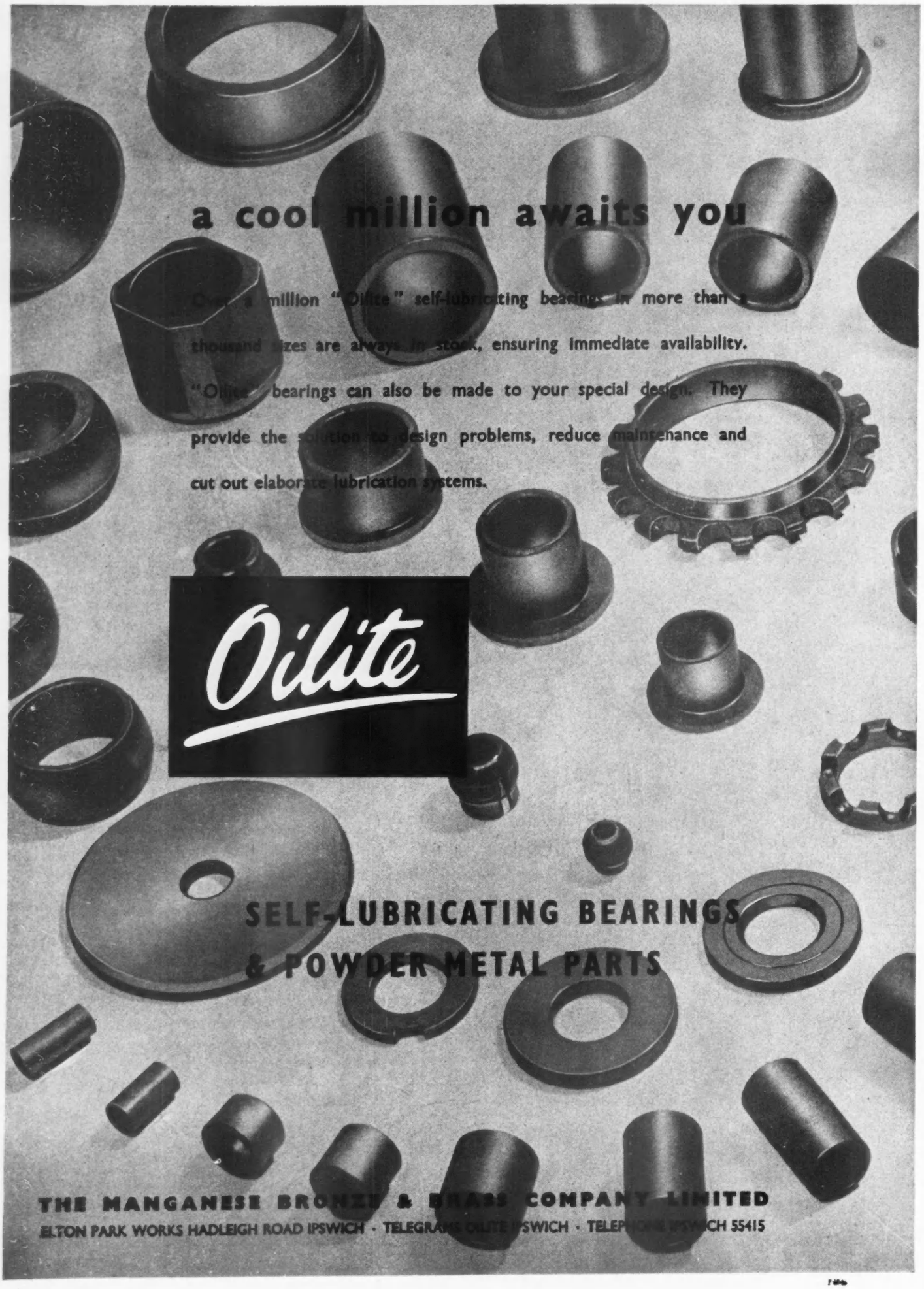
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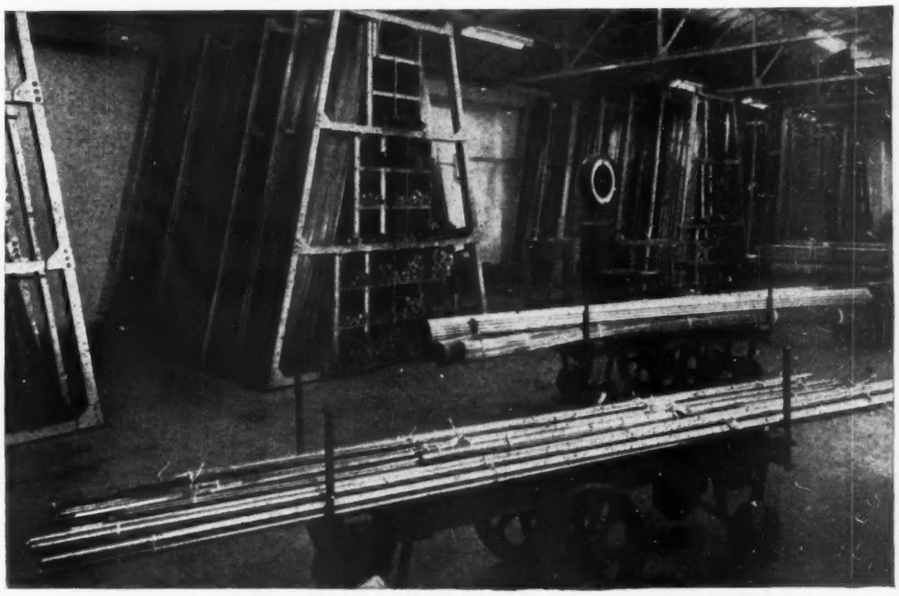

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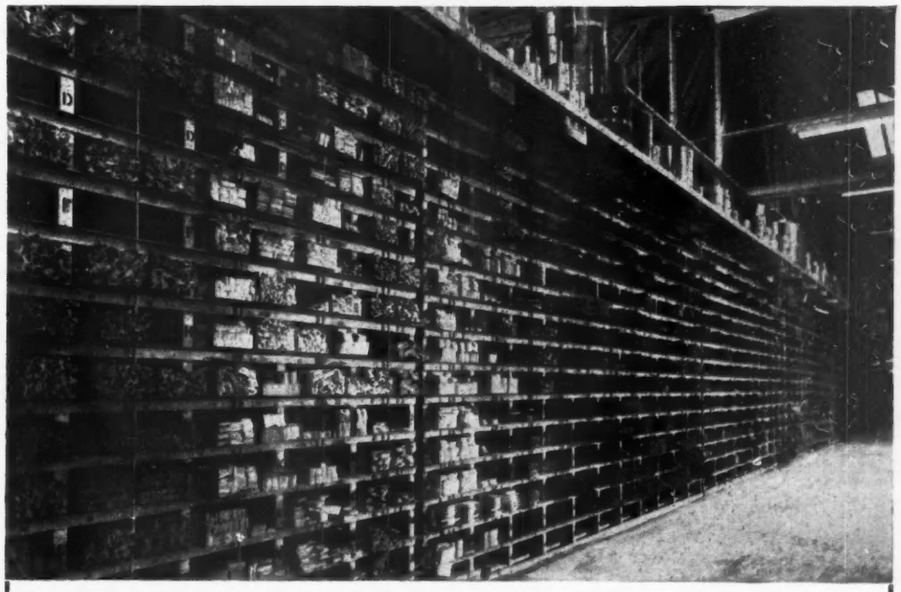

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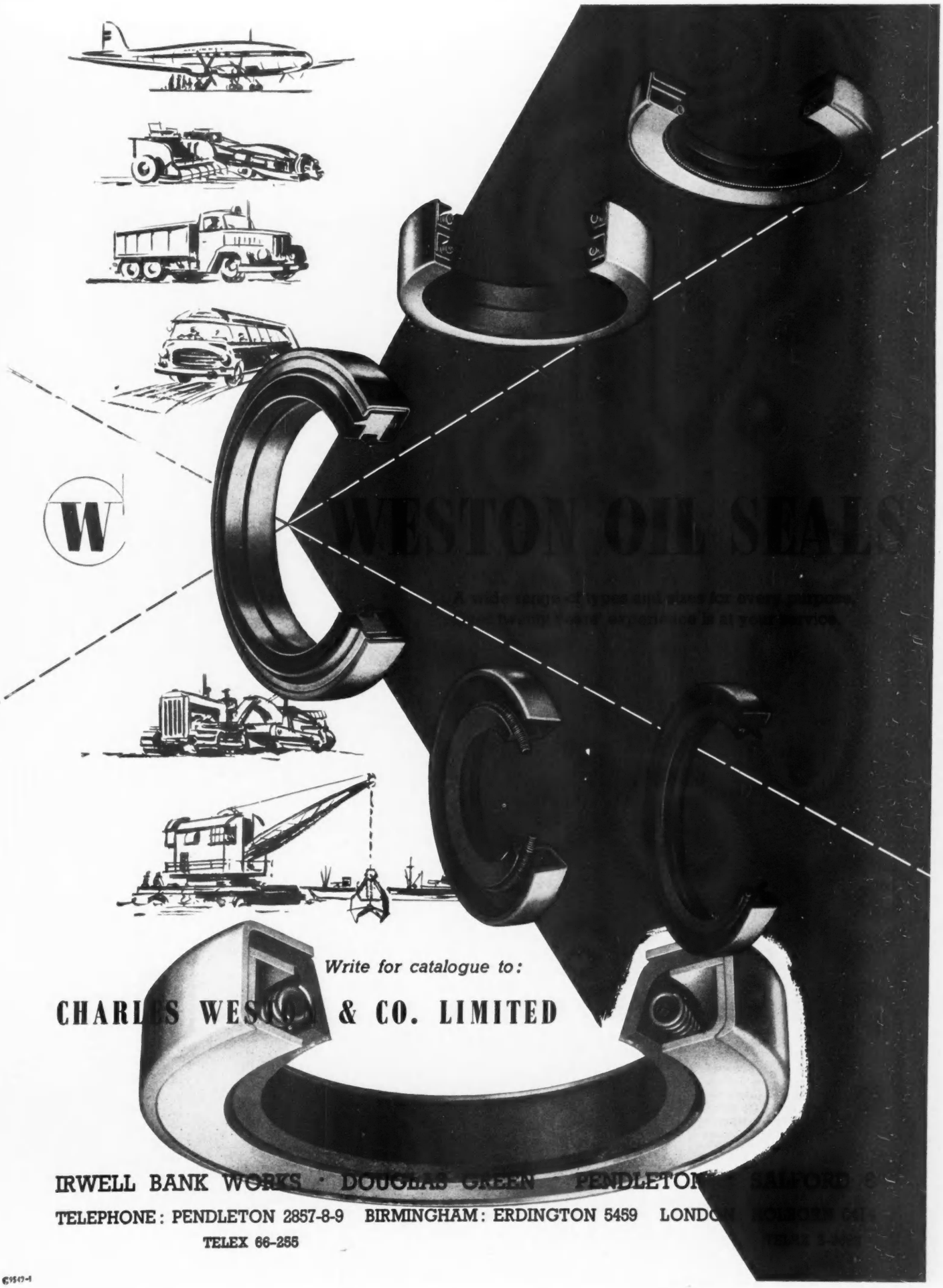

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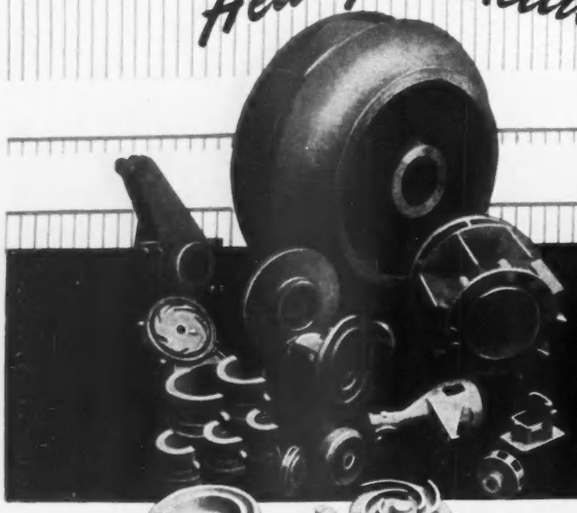

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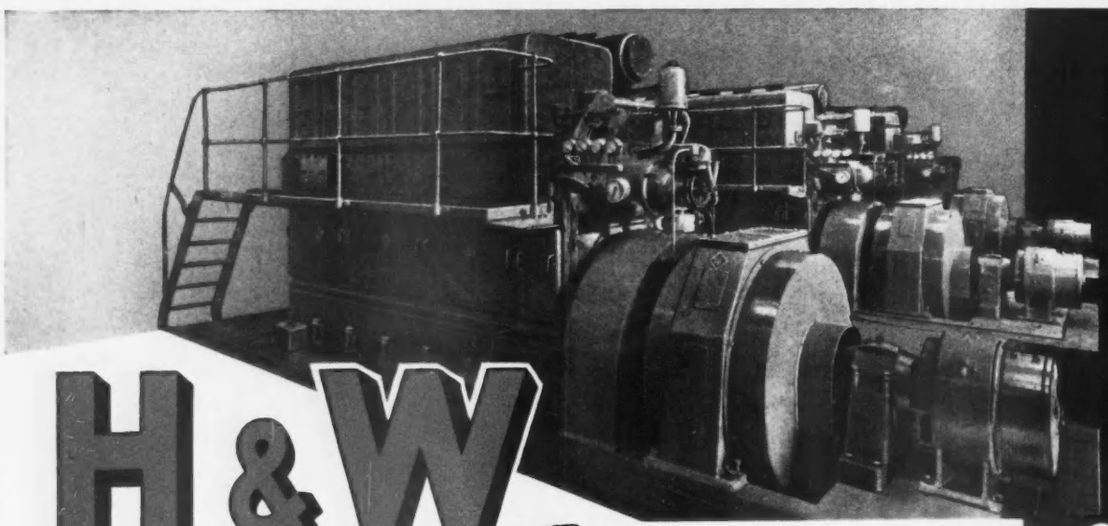

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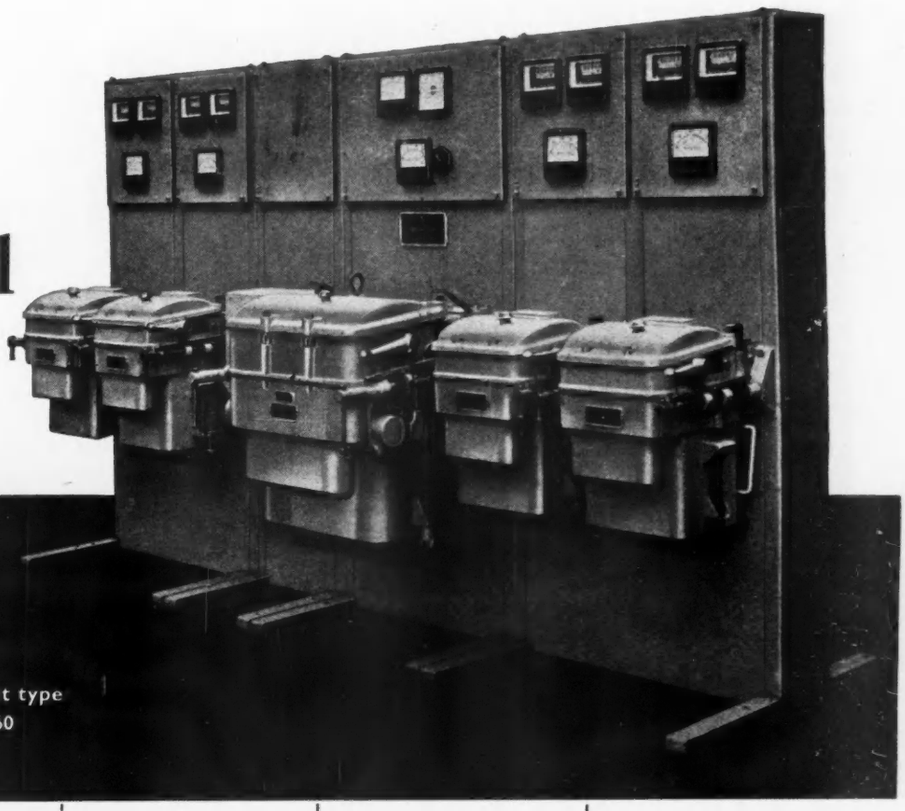

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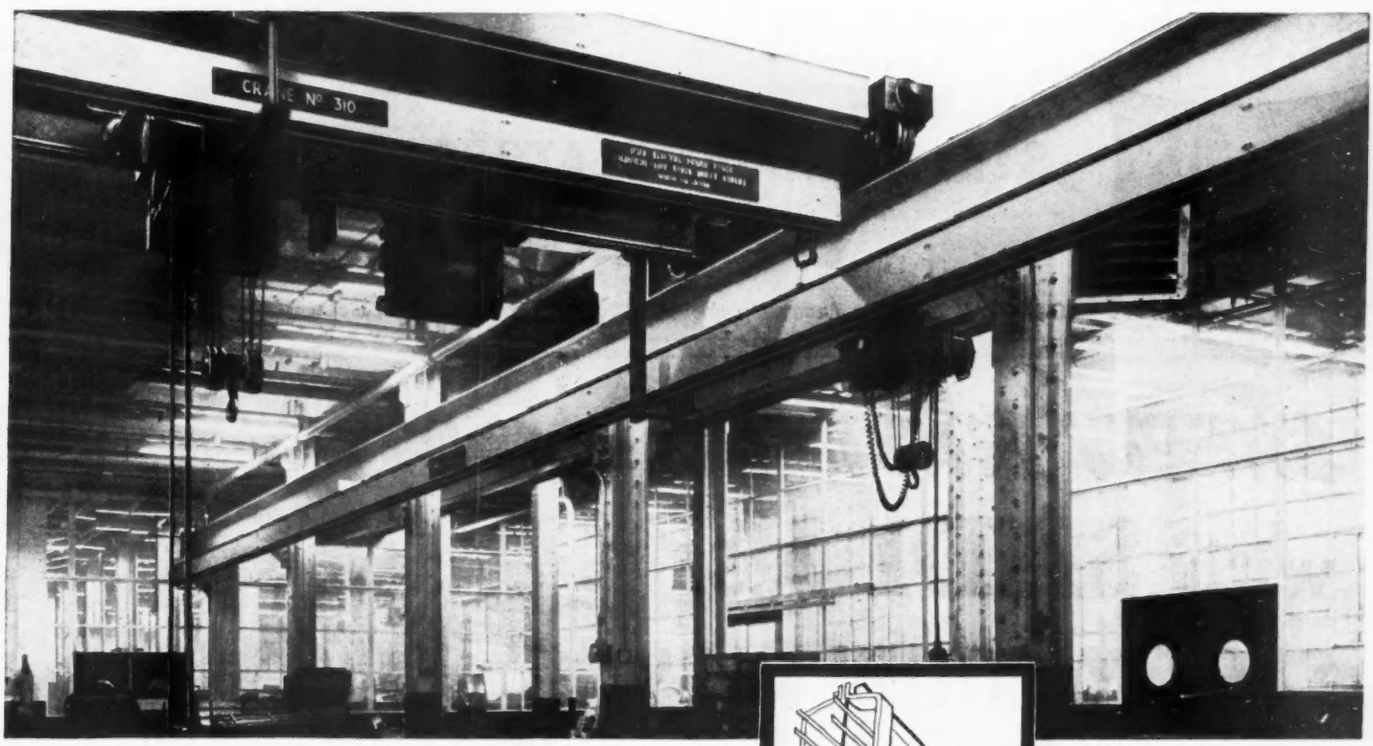

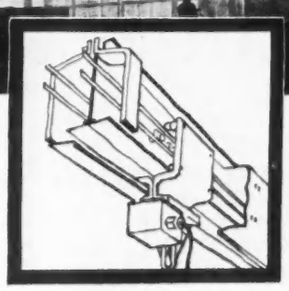

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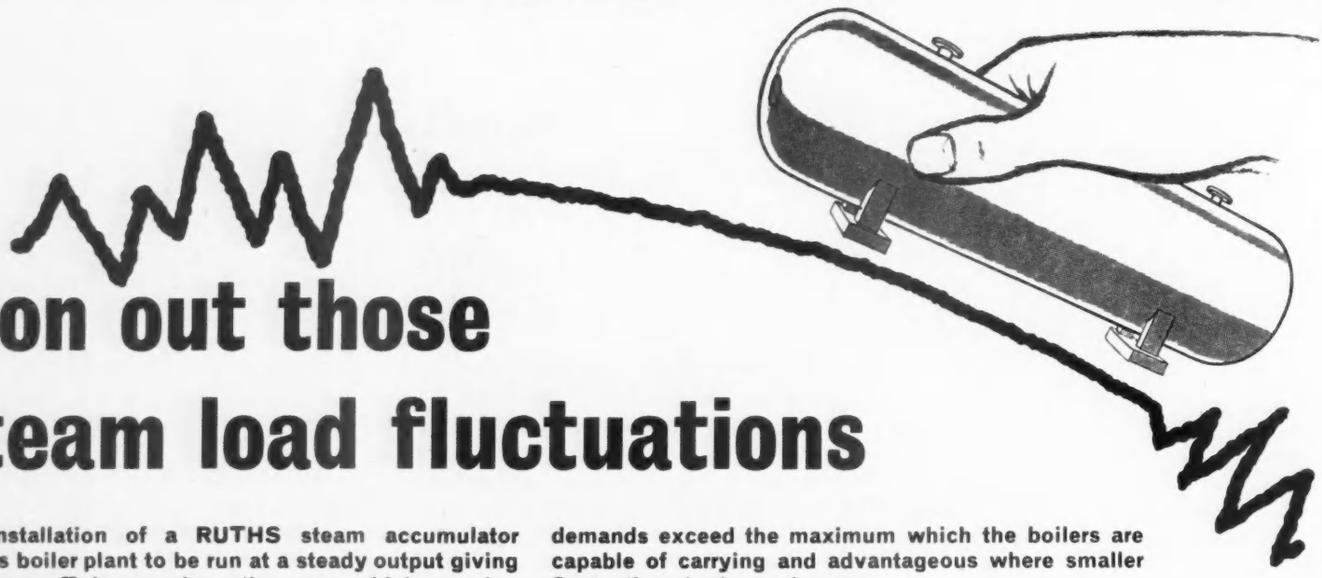

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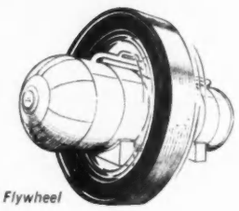

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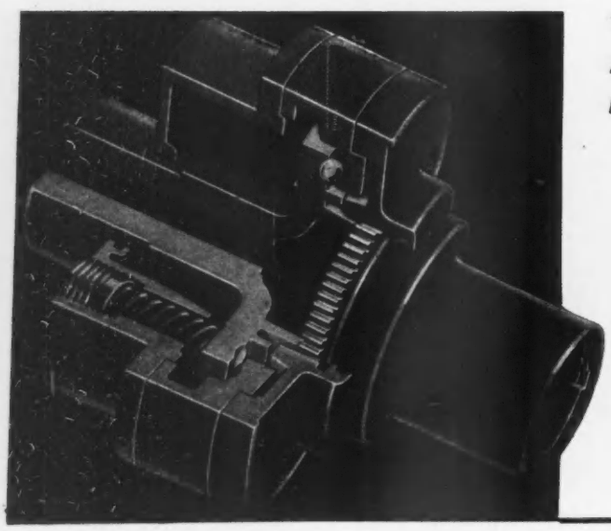

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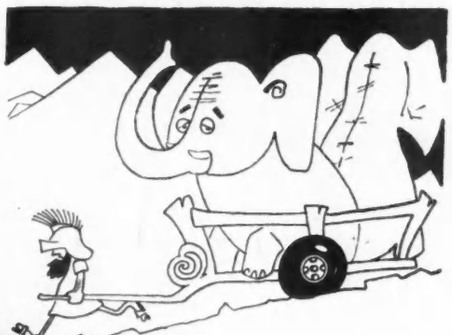

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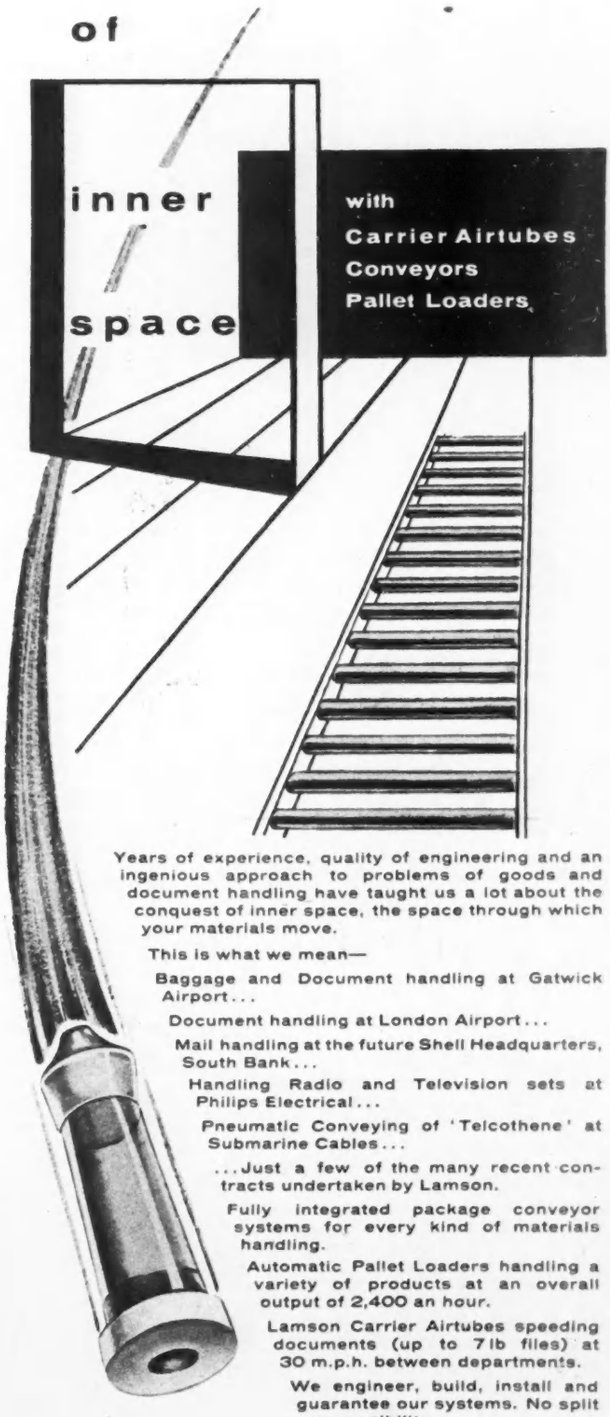

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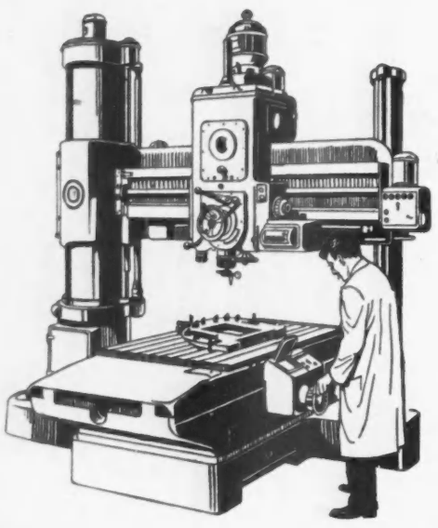

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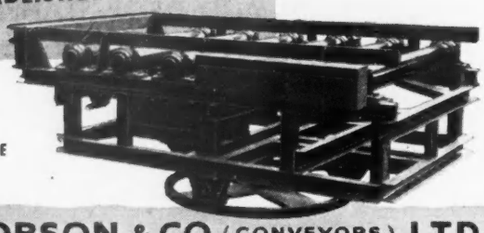

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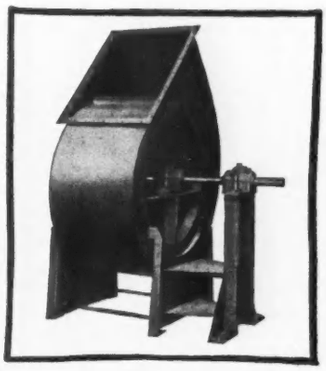
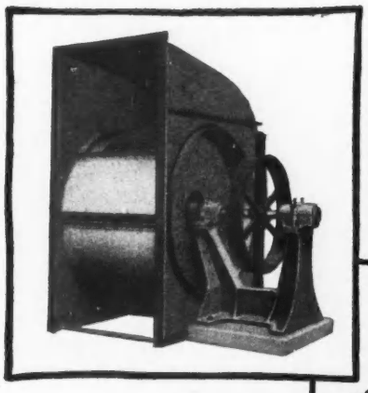
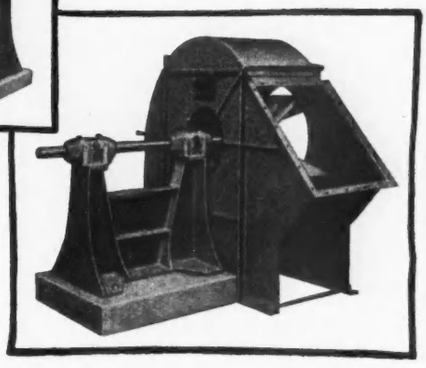


SLOW SPEED MULTIVANE FAN (Intermediate size).



SLOW SPEED MULTIVANE FAN (Large size).

Air ways



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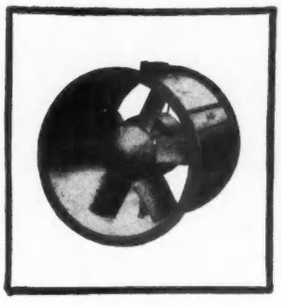
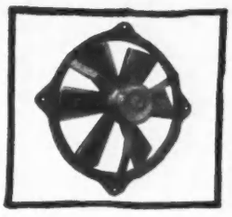
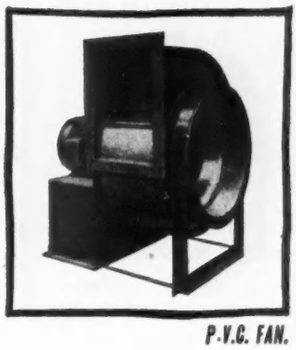


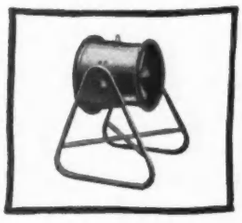
AXIAL FLOW FAN.



PROPELLER FAN.



P.V.C. FAN.



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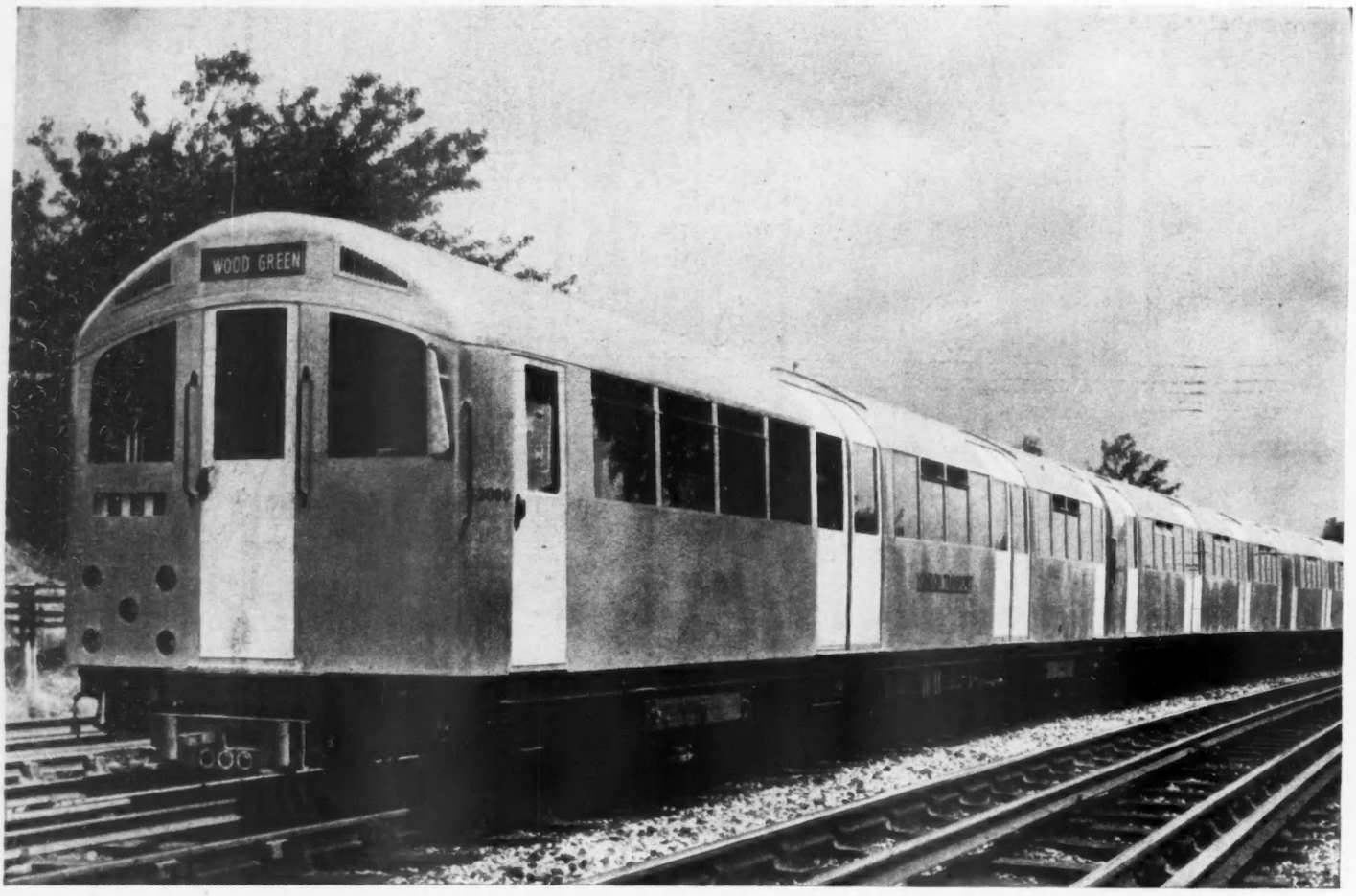

London Transport prototype tube train

The London Transport Executive are trying out three prototype tube trains with unpainted aluminium alloy outer panelling. British Aluminium was chosen by the manufacturers of two of these trains—Metropolitan-Cammell Carriage & Wagon Co. Ltd., and Gloucester Railway Carriage & Wagon Co. Ltd.
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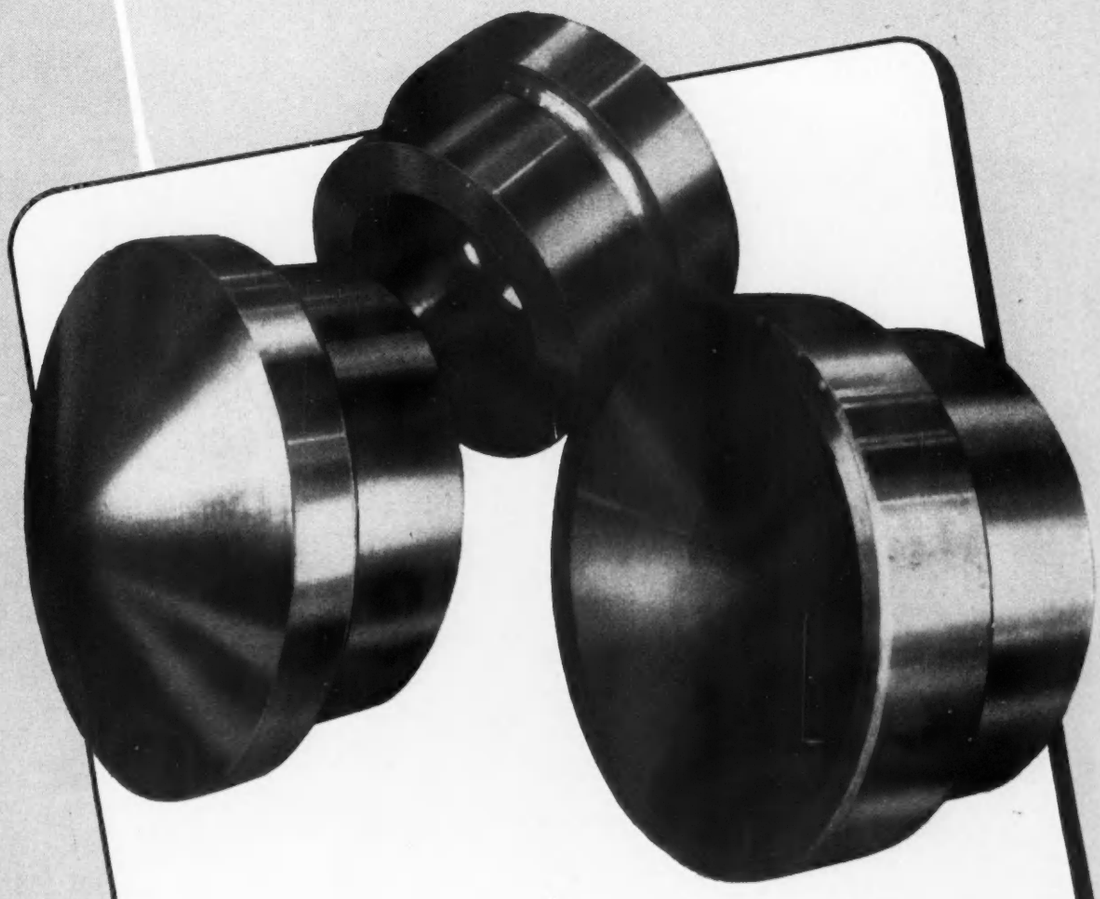

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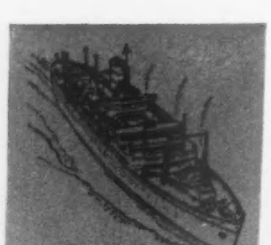

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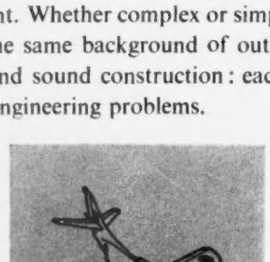
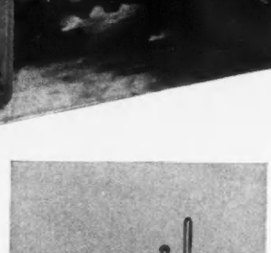
In developing power station auxiliary plant to match the advances in high efficiency turbo-alternators and boilers, Vickers-Armstrongs can draw on an outstanding background of engineering achievement. History-making aircraft like the Viscount and Valiant... fast ocean liners such as the 29,000-ton 'Orsova'... these are headline news. Yet, in their own fields, hundreds of other products of Vickers-Armstrongs are equally important. Whether complex or simple, each shares the same background of outstanding design and sound construction: each solves critical engineering problems.





Power station plant designed and constructed by Vickers-Armstrongs is noted for its efficiency and dependability. The range of equipment includes condensers, feed heaters, de-aereators, evaporating plant and circulating water pumps. In the last few years, the contracts received by the company for this type of plant from the Central Electricity Authority and from overseas organisations involve power stations whose total output is nearly 3,000,000 kW.

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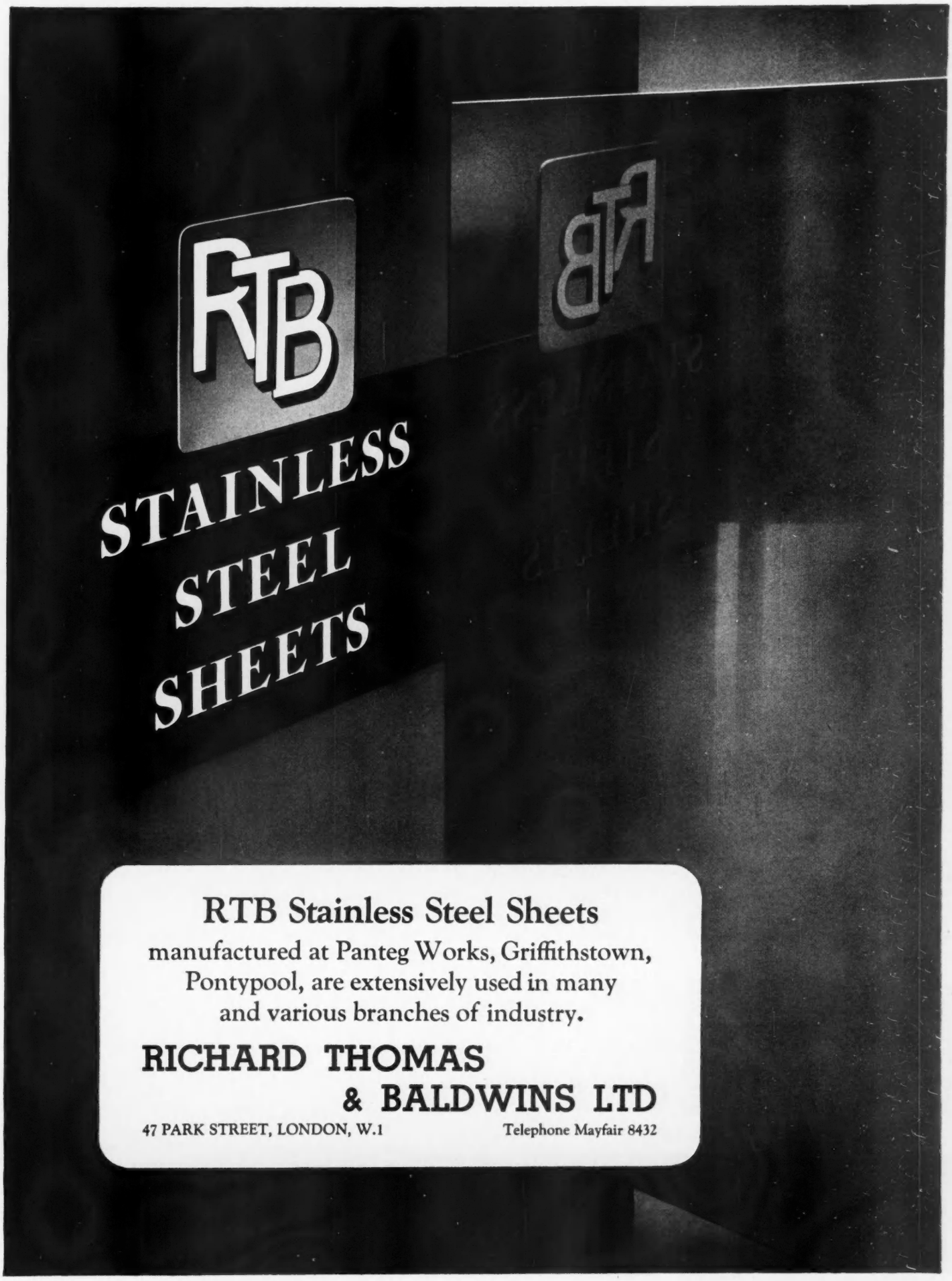

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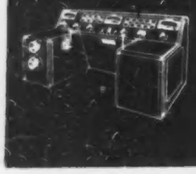

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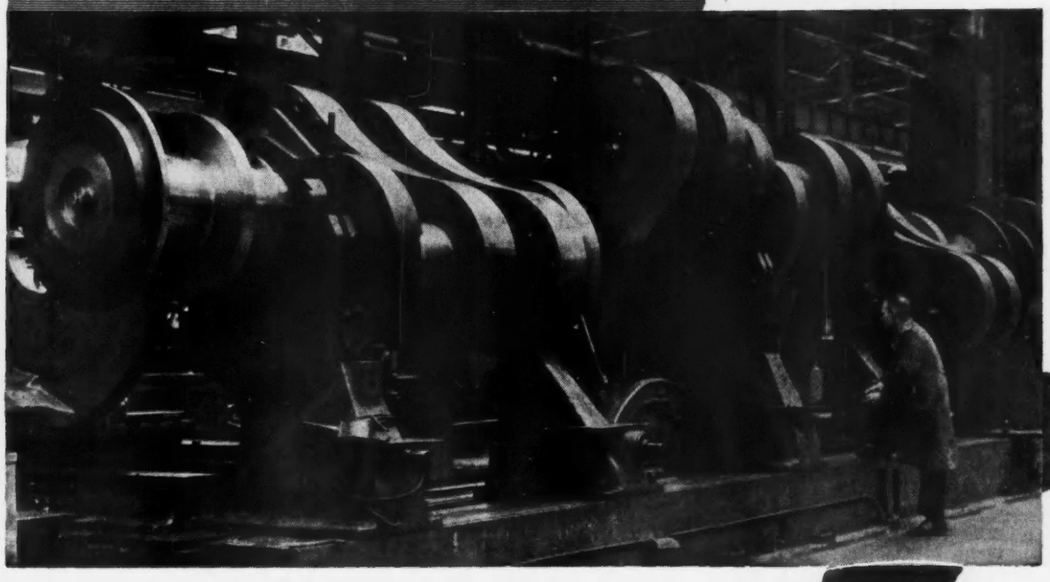

STEEL CASTINGS

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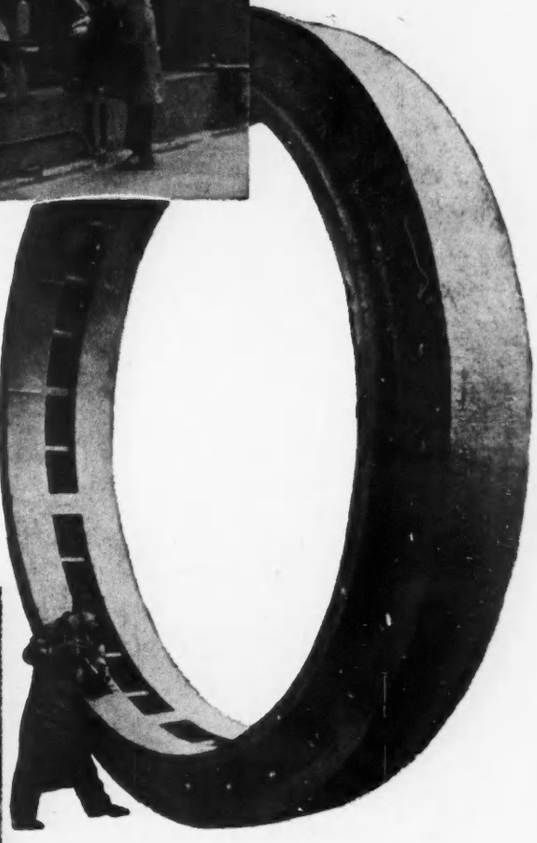

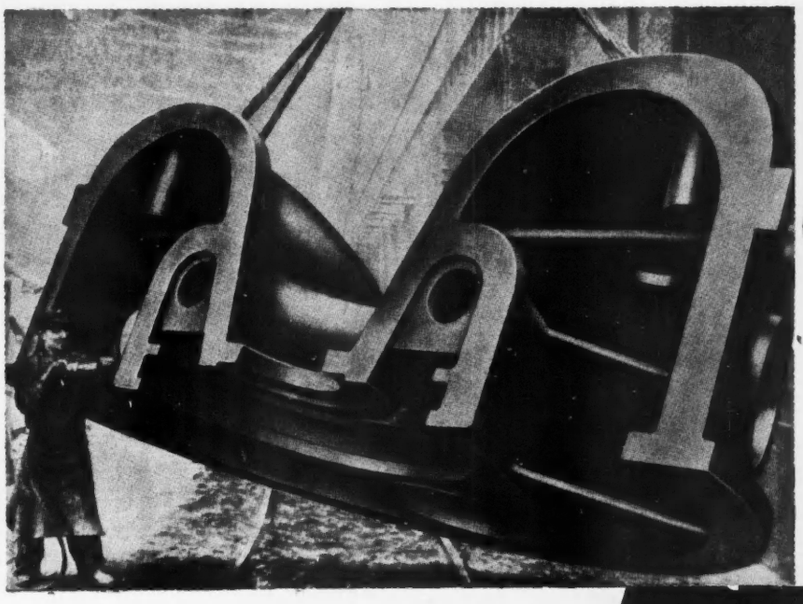

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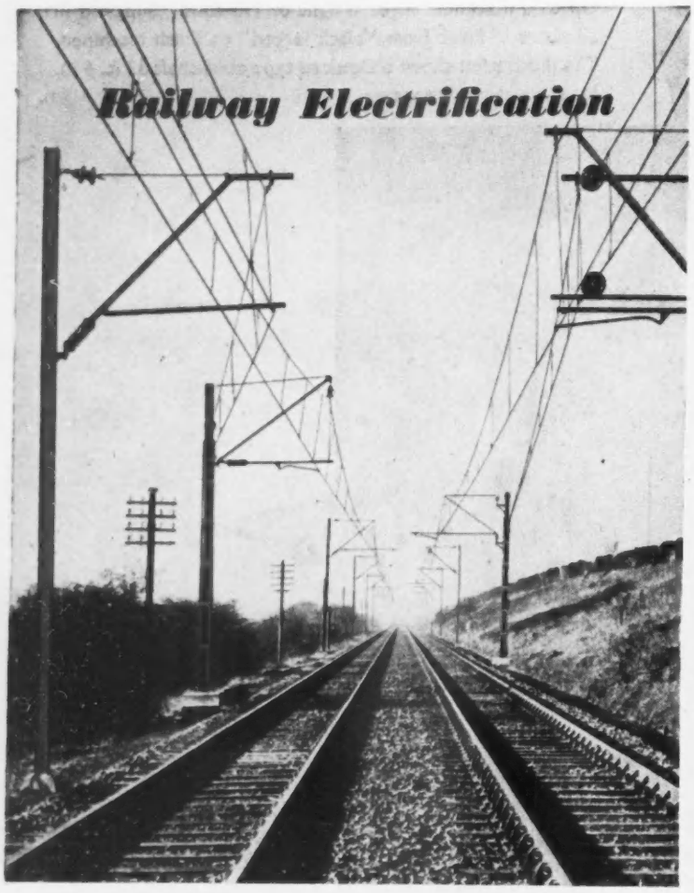

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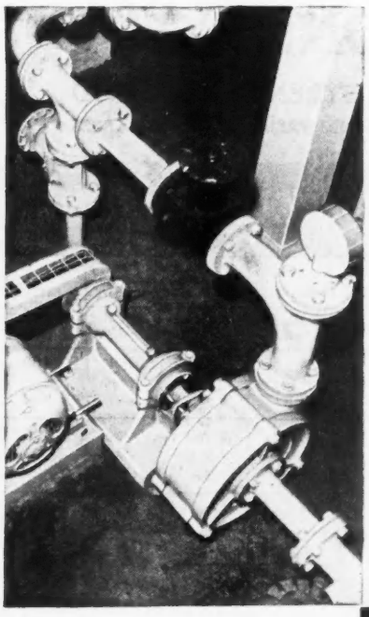

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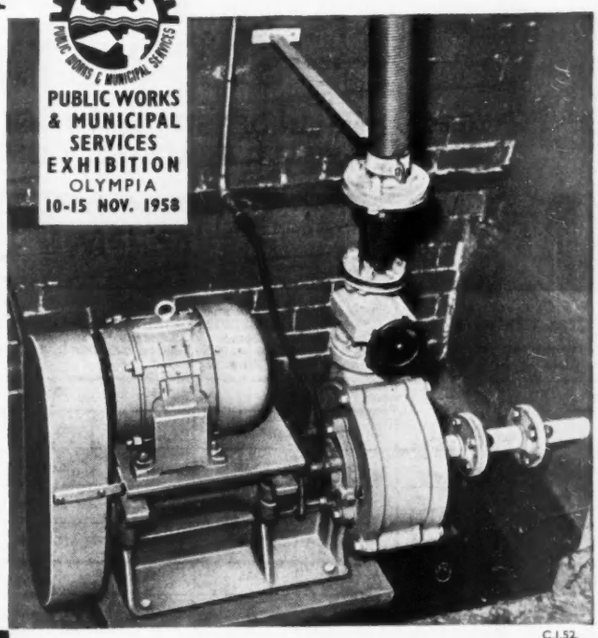

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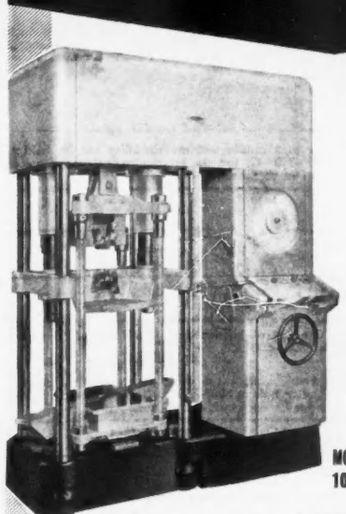

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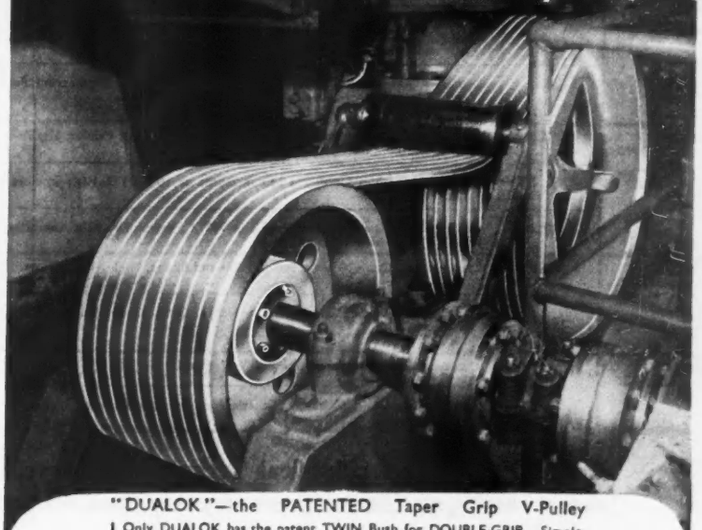

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TYPICAL PHYSICAL PROPERTIES OF "CORTITE" SPECIAL PROCESS IRONS

CORTITE IRON		Minimum TENSILE Strength Tons sq. inch 1·2" diam. Bar	Minimum TRANSVERSE Rupture Tons sq. inch 1·2" diam. Bar	COMPRESSION Strength Tons sq. inch	IMPACT Strength Izod ft. lbs.	BRINELL Hardness No.	Modulus of ELASTICITY lbs. sq. inch × 10⁶	SPECIFIC GRAVITY	Coefficient of Thermal EXPANSION Linear × 10⁶ 0—600°C.	TORSIONAL STRENGTH lbs. sq. inch	FATIGUE STRENGTH Tons sq. inch	The equivalent British and American Standards		PATTERN SHRINKAGE Inches per foot
Class	Grade											B.S.S. 1452/1956	A.S.T.M.	
HIGH DUTY ENGINEERING	E	14	26	56	10	170–190	12–15	7·20	—	—	5·0	14	25–30	1/10
	D	17	30	68	15	180–210	16–18	7·25	—	34,000	7·0	17	35–40	1/10
	C	20	36	75	20	200–240	18–20	7·40	—	51,000	9·0	20	40	1/8
	B	23	40	80	25	220–280	18–20	7·45	—	60,000	10·0	23	50	1/8
	A	26	45	90	30	260–340	18–20	7·45	—	73,000	11·0	26	60	1/8–3/16
HEAT RESISTING	HR.1	14	26	56	10	100–170	10–12	7·00	12·8	—	—	—	—	1/10
	HR.2	20	36	75	20	200–240	18–20	7·40	12·8	—	—	—	—	1/10–1/8
	HR.3 (Silal)	12	—	—	—	210–280	17–45	6·9–7·2	12·9	—	—	—	—	1/8
WEAR RESISTING	W.R.B.	20	36	75	20	240–280	18–20	7·40	—	—	—	—	—	1/8
	W.R.A.	26	45	90	30	260–340	18–20	7·45	—	—	—	—	—	1/8–3/16
CORROSION RESISTING	C.1	18	30	62	10	180–210	12–15	7·15	—	—	—	—	—	1/10
	C.2	15	28	58	10	180–210	12–15	7·15	—	—	—	—	—	1/10

TYPICAL APPLICATIONS OF "CORTITE" SPECIAL PROCESS IRONS

CORTITE IRON		TYPICAL APPLICATIONS	Minimum Casting Thickness	HEAT TREATMENT (optional)
Class	Grade			
HIGH DUTY ENGINEERING	E	Gear Cases, Light Valves, Gears, Electrical Components, Bogie Wheels, etc. ; in fact, wherever a soft grey iron is called for.	1/8"	For stress relief heat slowly to 450°–500° C. Hold at this temperature for one hour per inch of section. Cool slowly.
	D	Valve Bodies, Gates, Covers, Medium Machine Bedplates, Chucks, Gears, and Housings ; Cylinder Liners, Blocks, and Manifolds. All medium size high-pressure castings.	1/4	
	C	Turbine Casings, Condenser Bodies, Tyre Moulds, Marking-off Plates, Propellers, Flywheels, Pump Bodies, Pistons, Large High-pressure Valves, Steam Chests, Biological Shields, Gears, Large Machine Bedplates, Headstocks, etc.	3/8"	For improved strength and toughness oil-quench at 850° C and temper at 300°–500° C to remove quenching stresses Grades C and B only.
	B	Diesel and Compressor Bodies (handling high-pressure ammonia and Freon gas), High-pressure Valves, Oil Well Castings, Slush Pumps, Gears, Machine Tool Components, Rocking Links, Highly Stressed Hydraulic Castings, Winch and Winding Drums, Rolls, etc.	1/2"	
	A	Crankshafts, Camshafts, Mixershafts, Dies, Rolls, Atomic Engineering Pressure Vessels, Shields, and Casings ; Brake Drums, High-pressure and High Strength Castings.	1/2"	For high tensile and machinability can be held at 300°–350° C, for six hours plus one hour for each inch of thickness.
HEAT RESISTING	HR.1	Intermittent Heat and Severe Thermal Shock, Chills, Ingot Moulds, Slag Pots, Annealing Glass Moulds, Fire Doors, Casings, Pig Moulds, Melting Pots, etc.	3/8"	—
	HR.2	High Duty Castings for use at temperatures up to 550° C, High-pressure Valves, Superheater Headers, Glass Moulds, etc.	1/2"	—
	HR.3	Castings working at temperatures up to 900° C, Valves, Fire Bars, Annealing Boxes, Furnace Parts. These castings are brittle at room temperature.	1/2"	—
WEAR RESISTING	WR.B	Chute Liners, Crane Wheels, Mill Wheels and Blades, Mixing Pans, Gears. Easily machinable.	1/2"	Can be oil-quenched at 850° C and tempered at 300°–500° C.
	WR.A	Mixer Blades, Wheels and Pans, Die Blocks, Cams, Gears, Liners, Rolls. High strength coupled with abrasion resistance.	1/2"	For high hardness castings, to improve machinability hold at 300°–350° C, for six hours plus one hour for each inch of thickness.
CORROSION RESISTING	C.1	Concentrated acid-resistant Pumps, Valves, etc.	1/4"	—
	C.2	Alkali-resistant Pumps, Valves, Caustic Pots, Evaporators, etc.	1/4"	—

New Alloys and Metallurgical Techniques employed in the process of producing these irons ensure consistent results, so that designers may rely upon the accuracy of the technical information given on the chart

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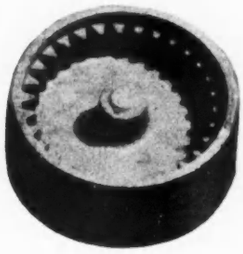
IN 'CORTITE' IRON



GEAR DRUM—GRADE E
These teeth must be cast true. They are not machined and must mesh perfectly.

CORTS THROTTLE VALVE—GRADE C.

PUMP CASTING—GRADE D.—(For Hayward, Tyler & Co., Ltd., Luton).

This 53 cwt. Vertical Compound Oil Cargo Pump is for use in tankers and handles 750 t.p.h. of oil. It is tested at 350 lb. p.s.i. for a working pressure of 200 lb. p.s.i.

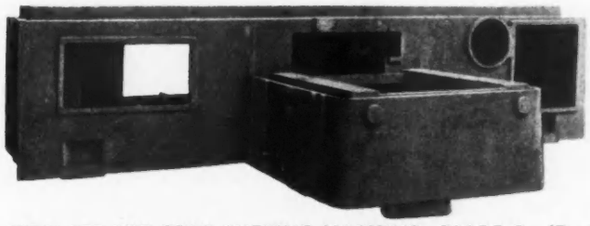
All the cores and the mould are made by the CO_2 process, which gives an excellent finish and ensures that the dimensions of cored holes are exact.

COMPRESSOR CYLINDER FOR REFRIGERATION EQUIPMENT—GRADE B.—(For Lightfoot Refrigeration, Ltd., Wembley).

This 15½ cwt. six-cylinder freon compressor casting must be completely flawless. The cylinders and crankcase, which are cast in one piece to ensure perfect alignment, are subject to hydraulic tests of 300 and 600 lb. p.s.i. respectively and gas tests of 250 lb. p.s.i.

MIXERSHAFT — GRADE A.—(For Winkworth Machinery, Ltd., Staines).
This Casting must be very strong, and 100% sound, to withstand severe Torque, replacing a steel casting.

CORTS DOUBLE GATE VALVE—GRADE HR.2
For use in hot gas main at temperatures of 550°-600° C.



BEDPLATE FOR GEAR CUTTING MACHINE—GRADE C.—(For W. E. Sykes, Ltd., Staines).

This 3-ton, 12ft. long bedplate casting is only ⅜in. thick and requires a very accurate mould and core, which, again, is achieved by the use of CO_2 process. Over 50 cores are needed to produce the intricate internal chambers.

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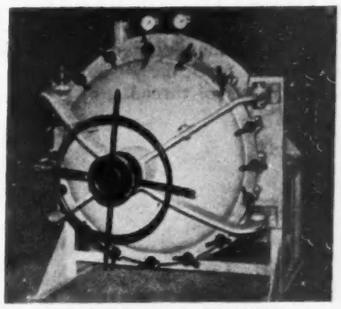

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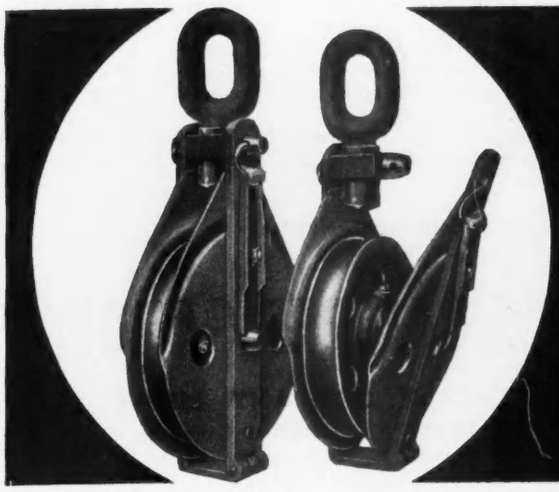

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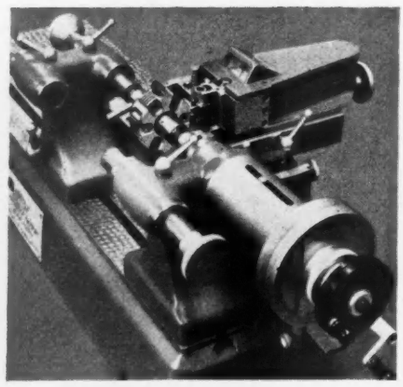

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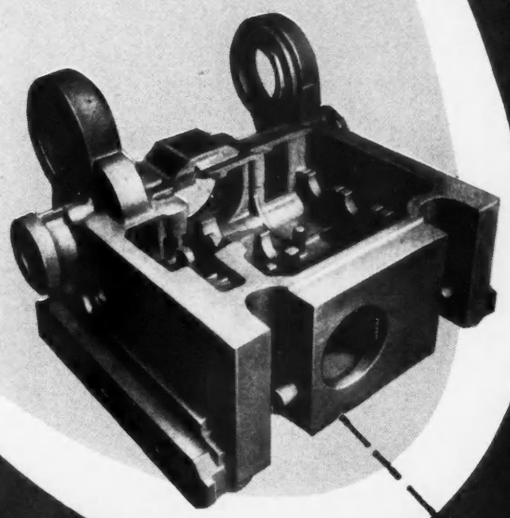

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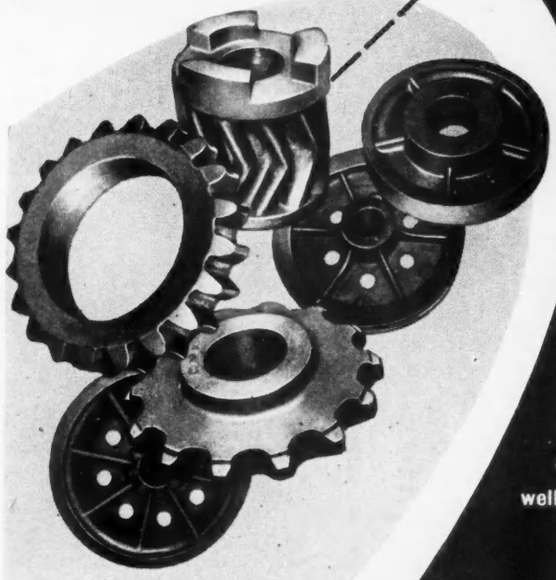

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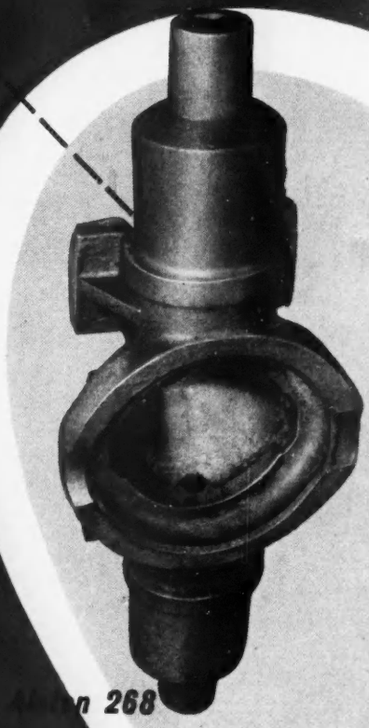

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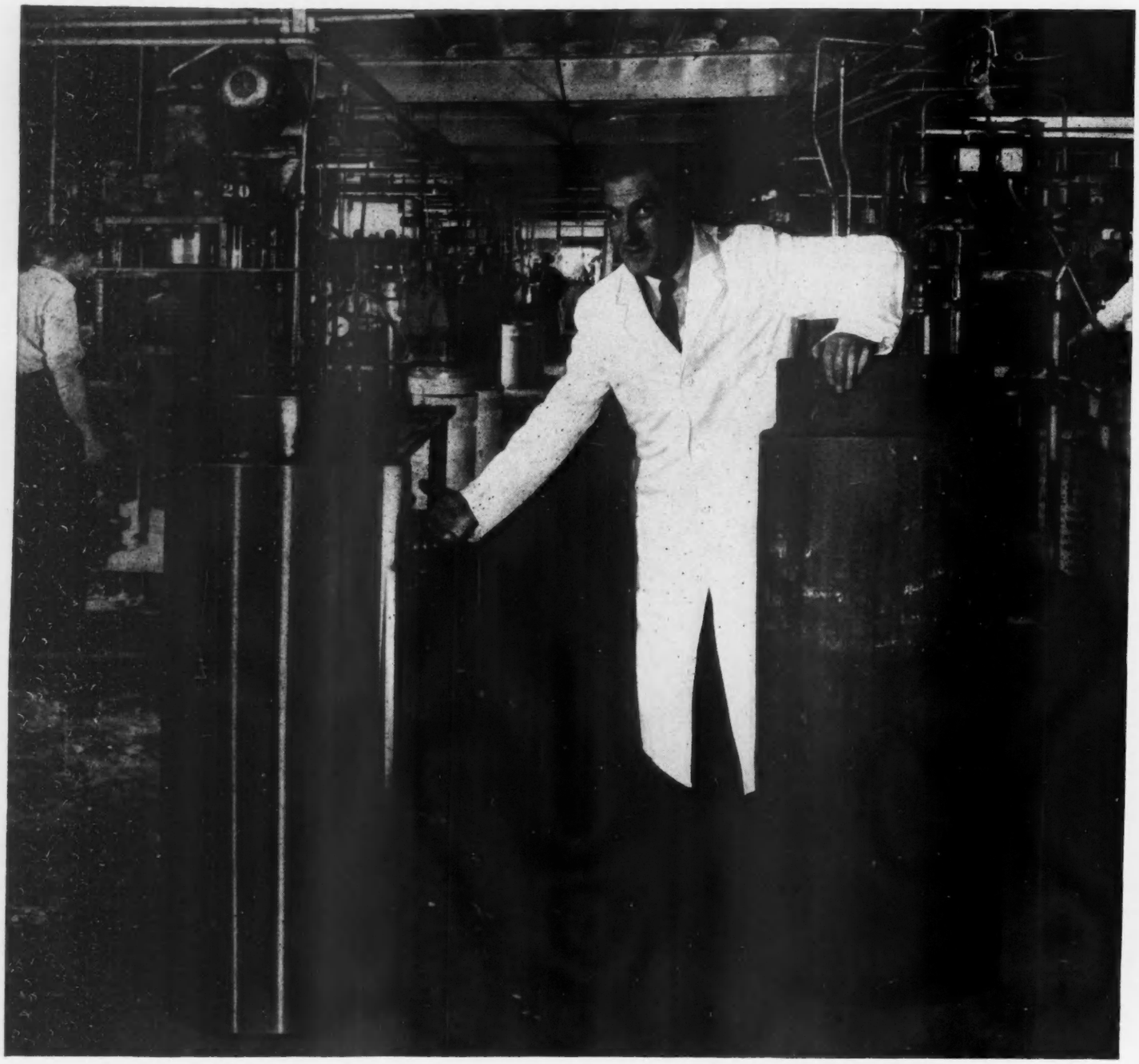

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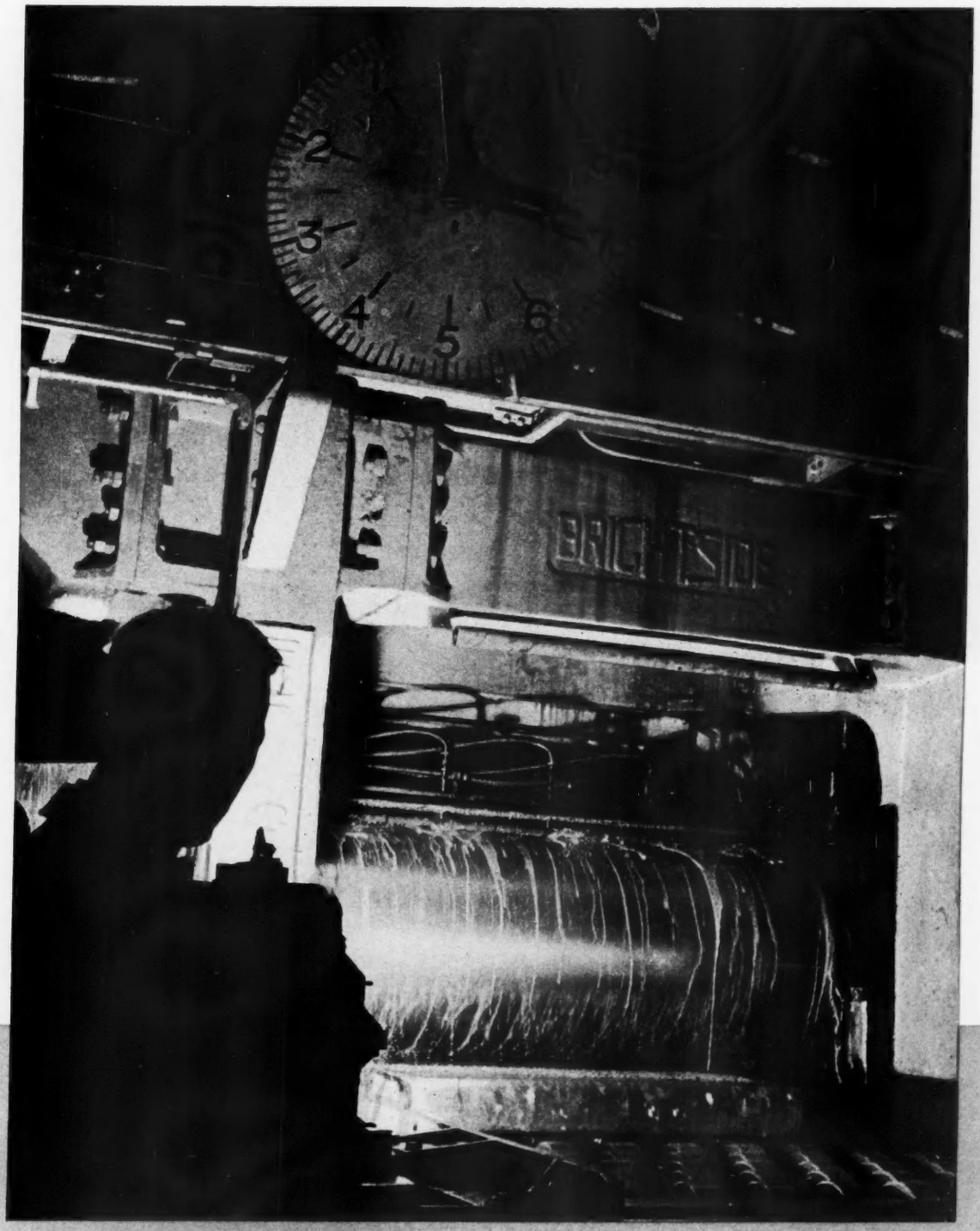

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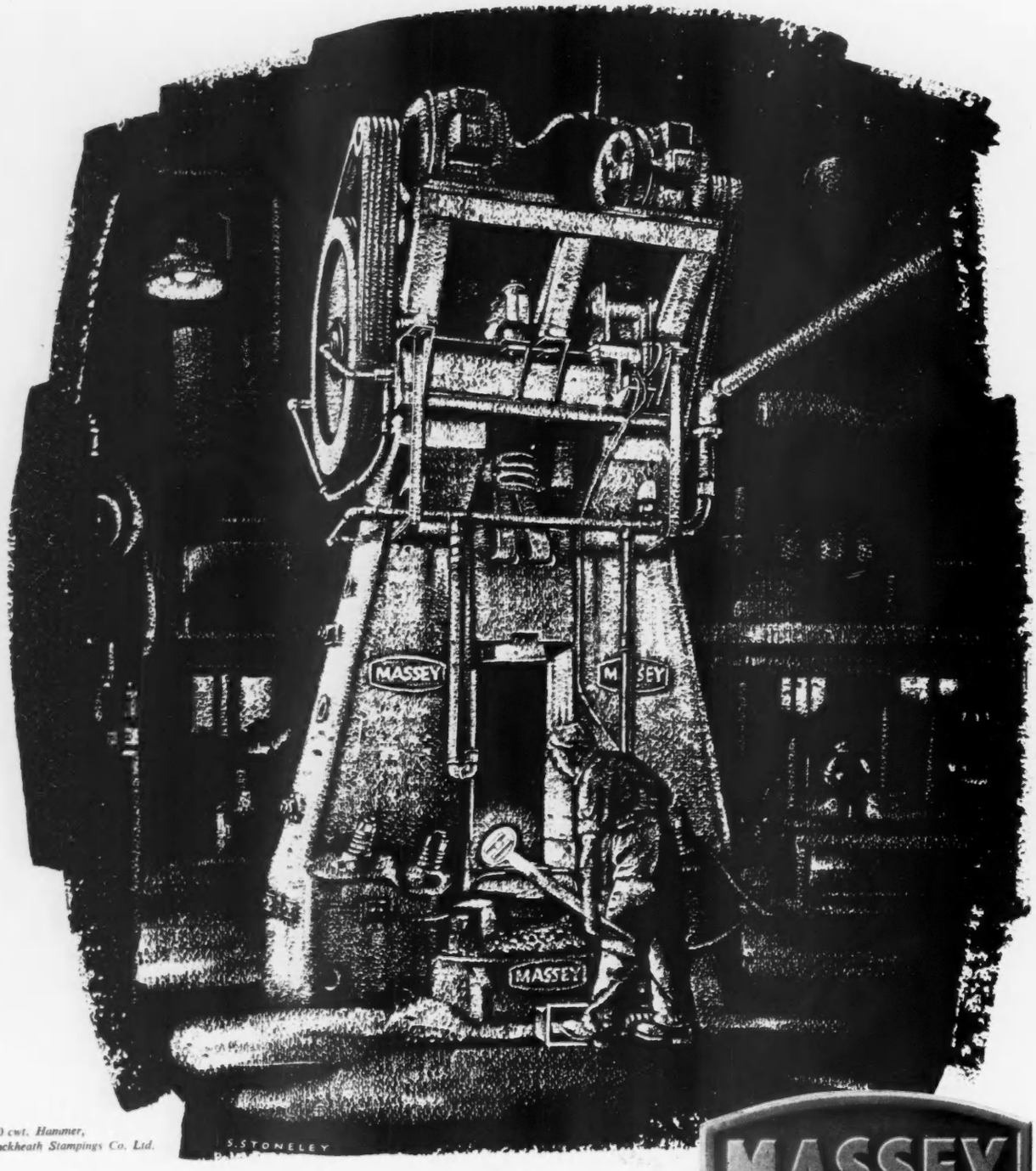

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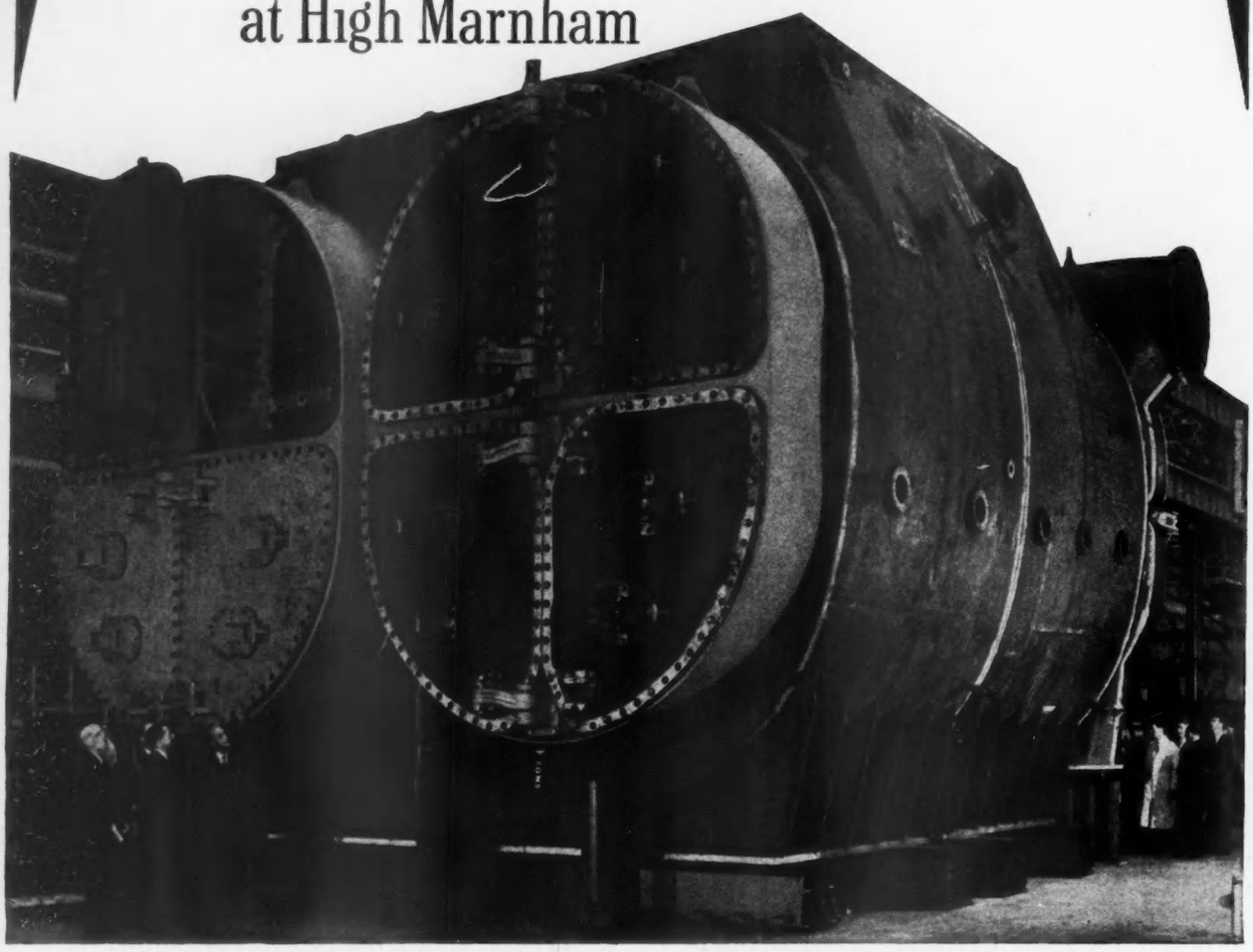

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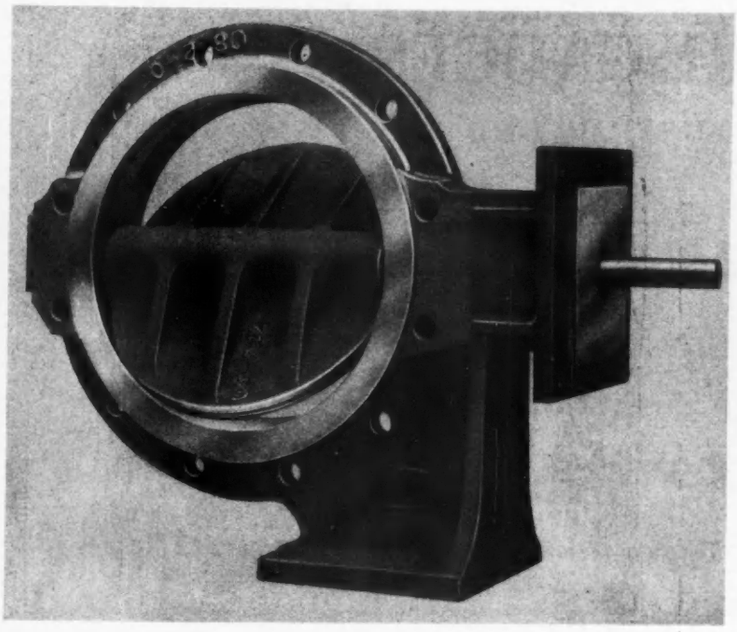

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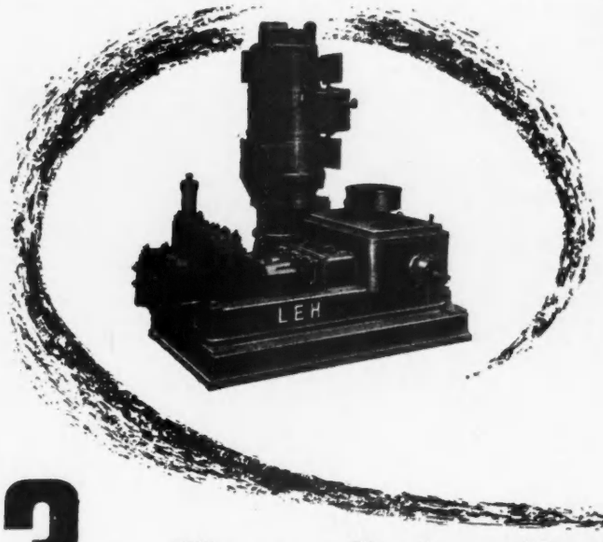

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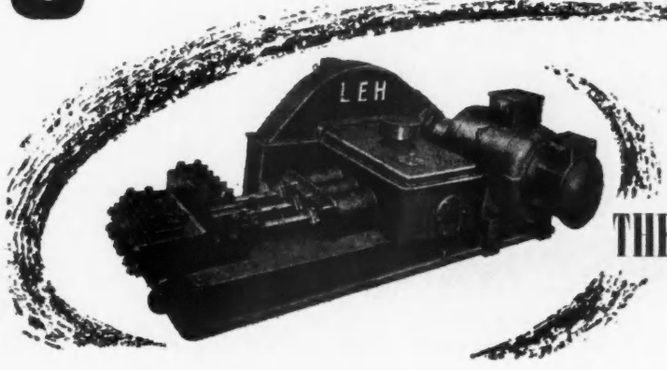

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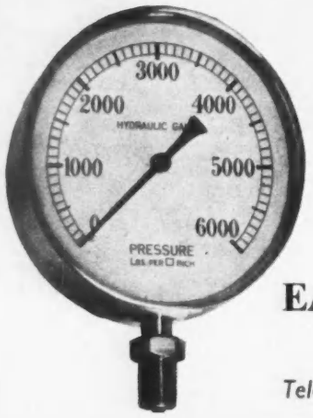

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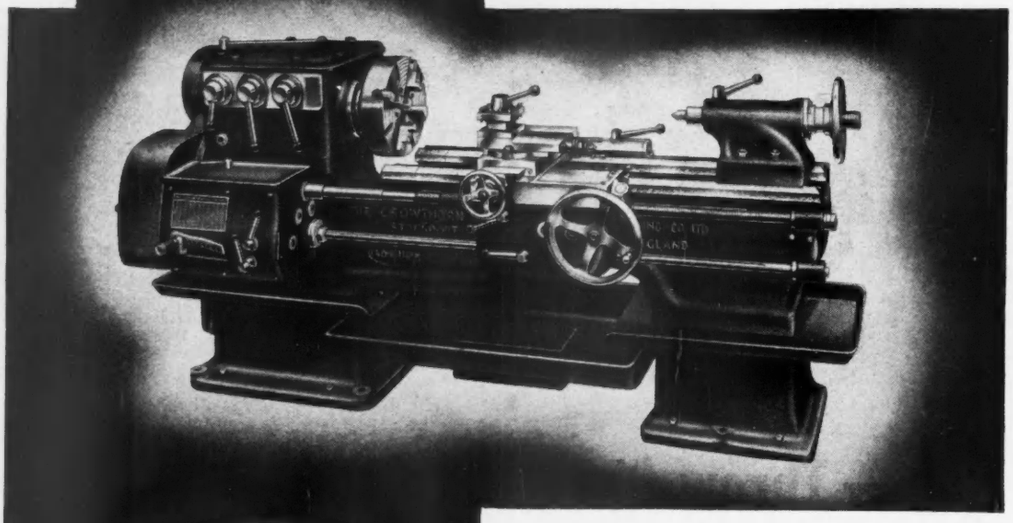

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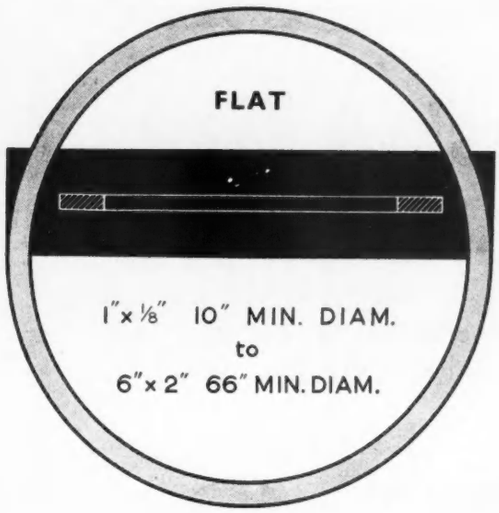

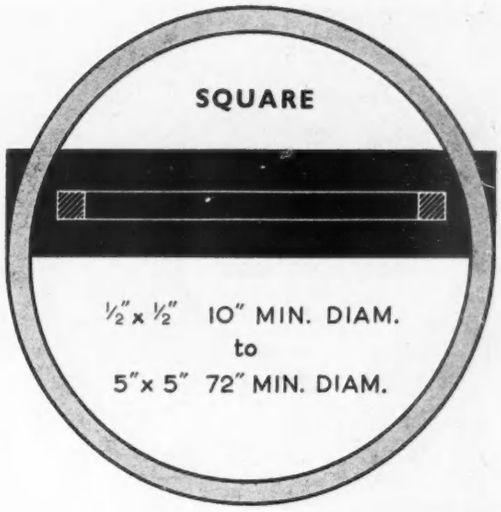

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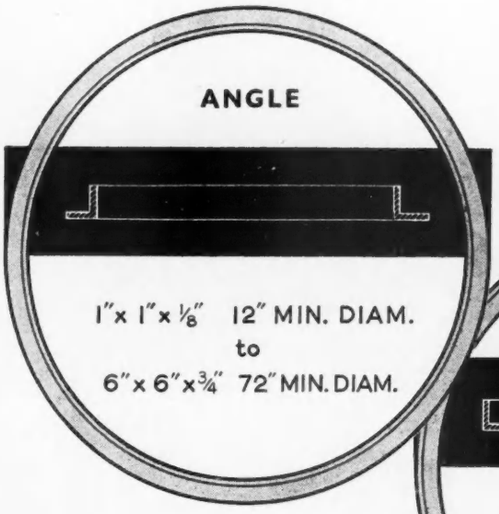

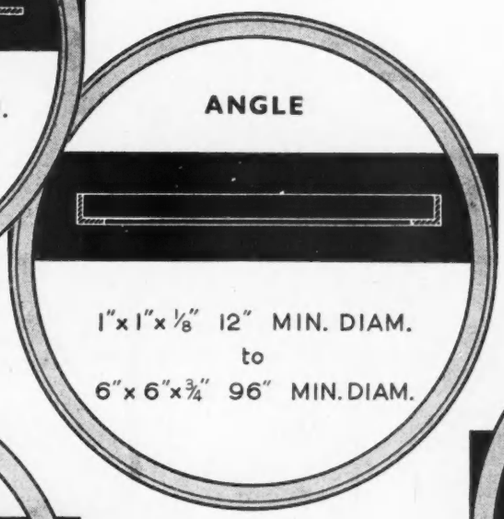

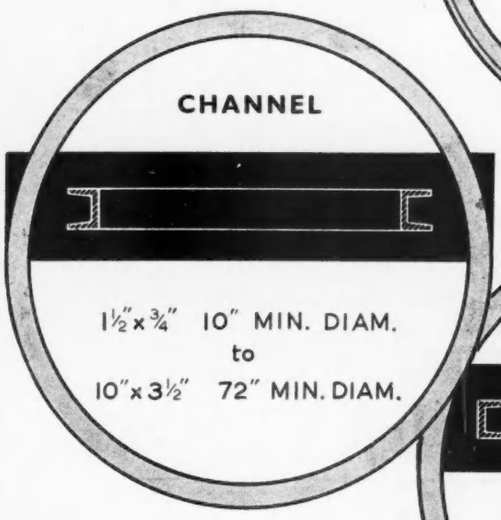

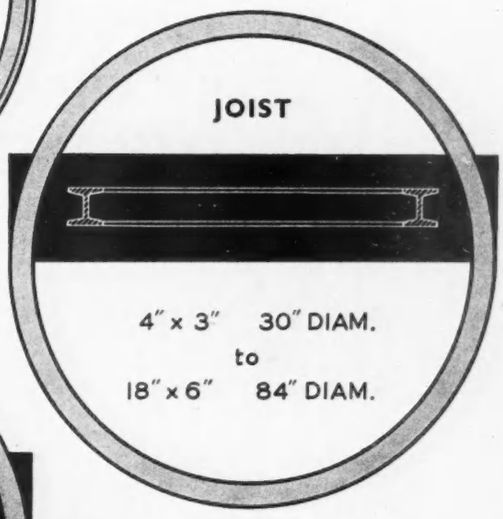

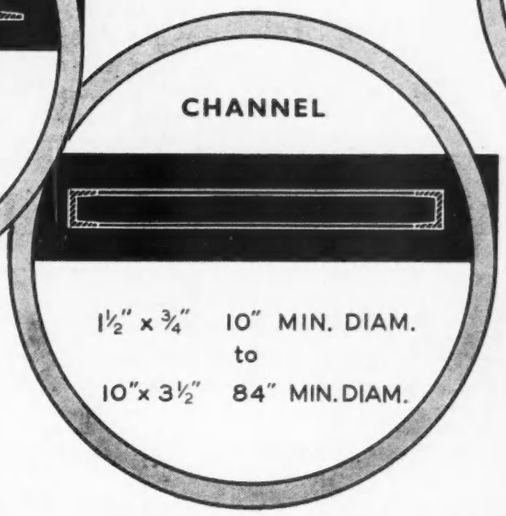

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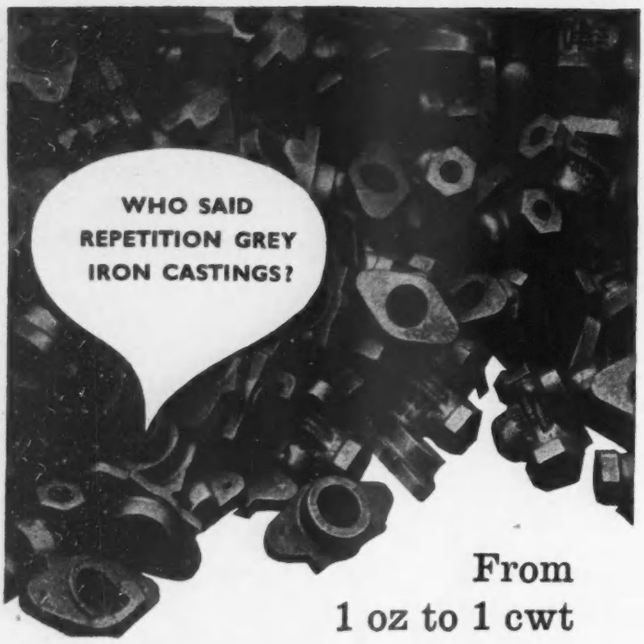

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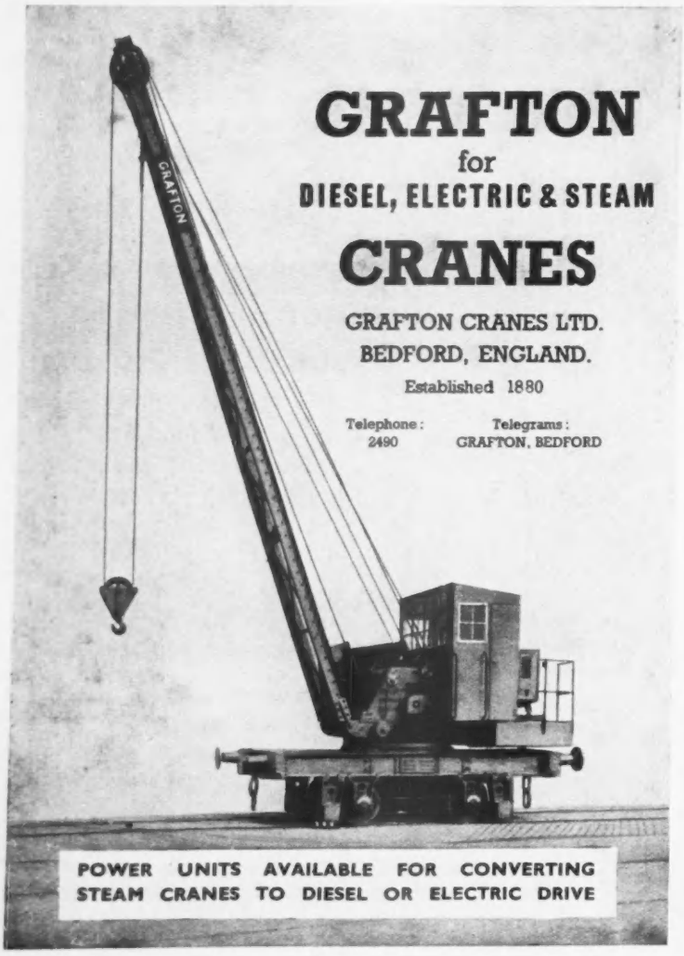

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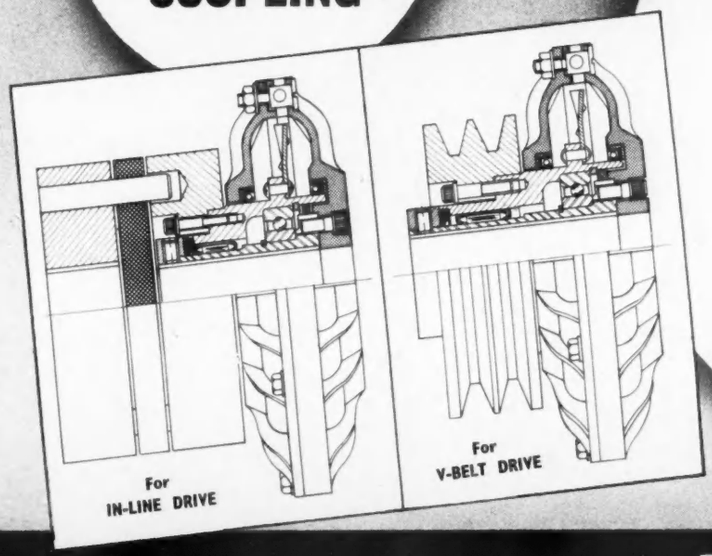

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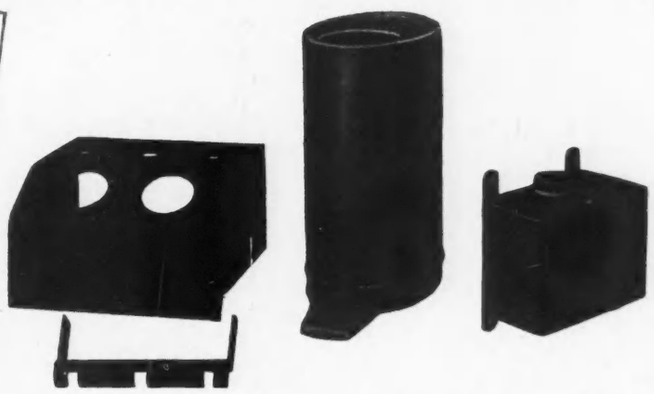

Examples of general sheet metal work shown here comprise an Air Compressor Control Panel, a High Pressure Grease Dispenser, and on the right, an Oil Tank used for the automatic lubrication of commercial vehicles.

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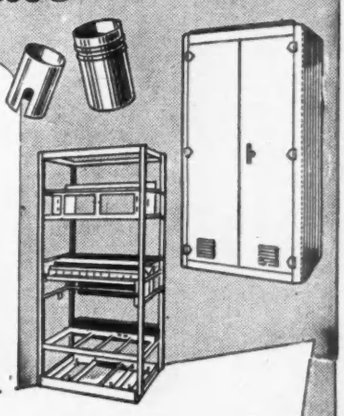

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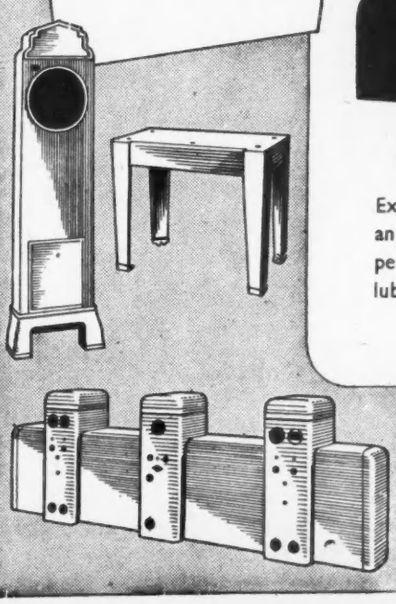

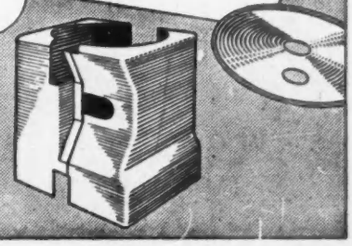

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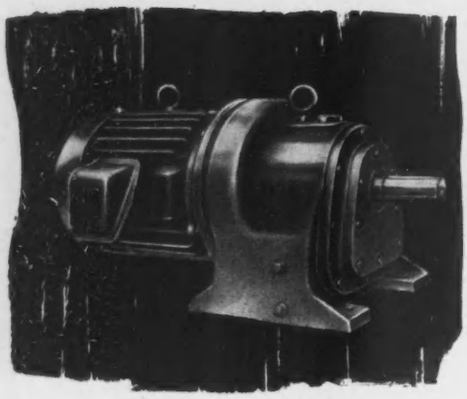
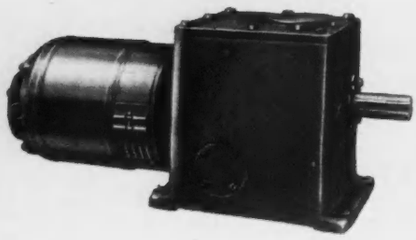
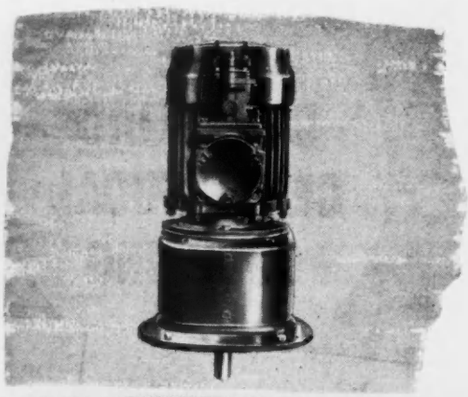
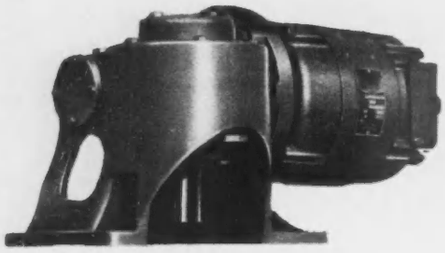
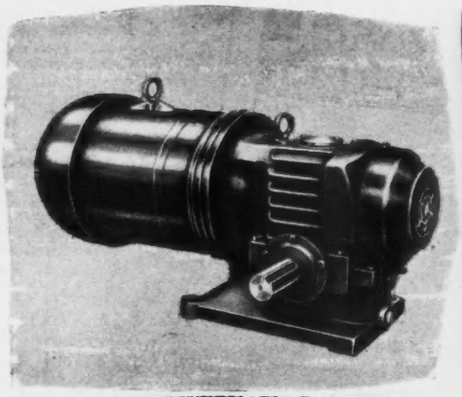

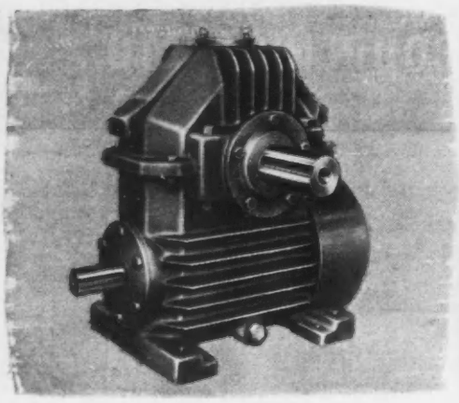
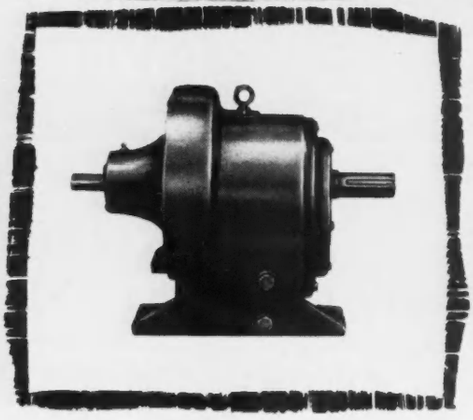
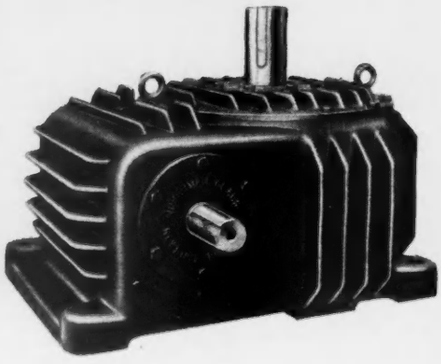

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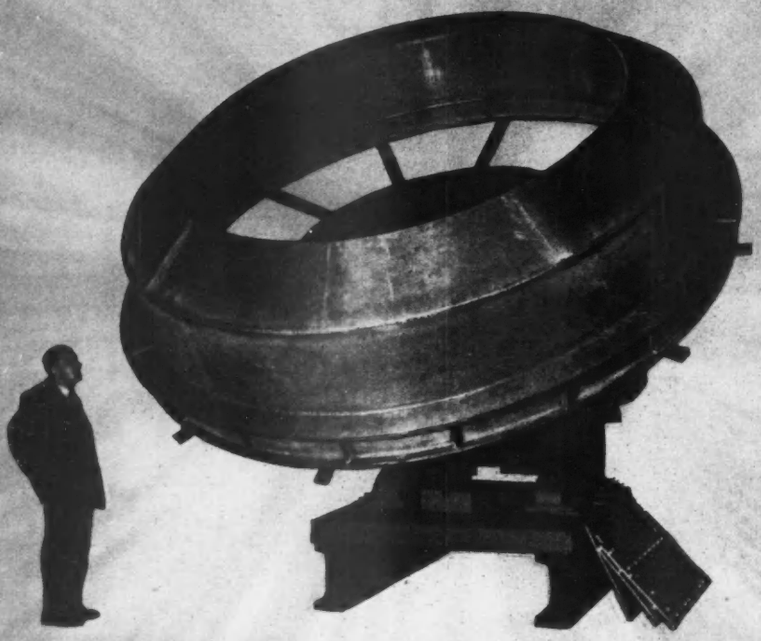

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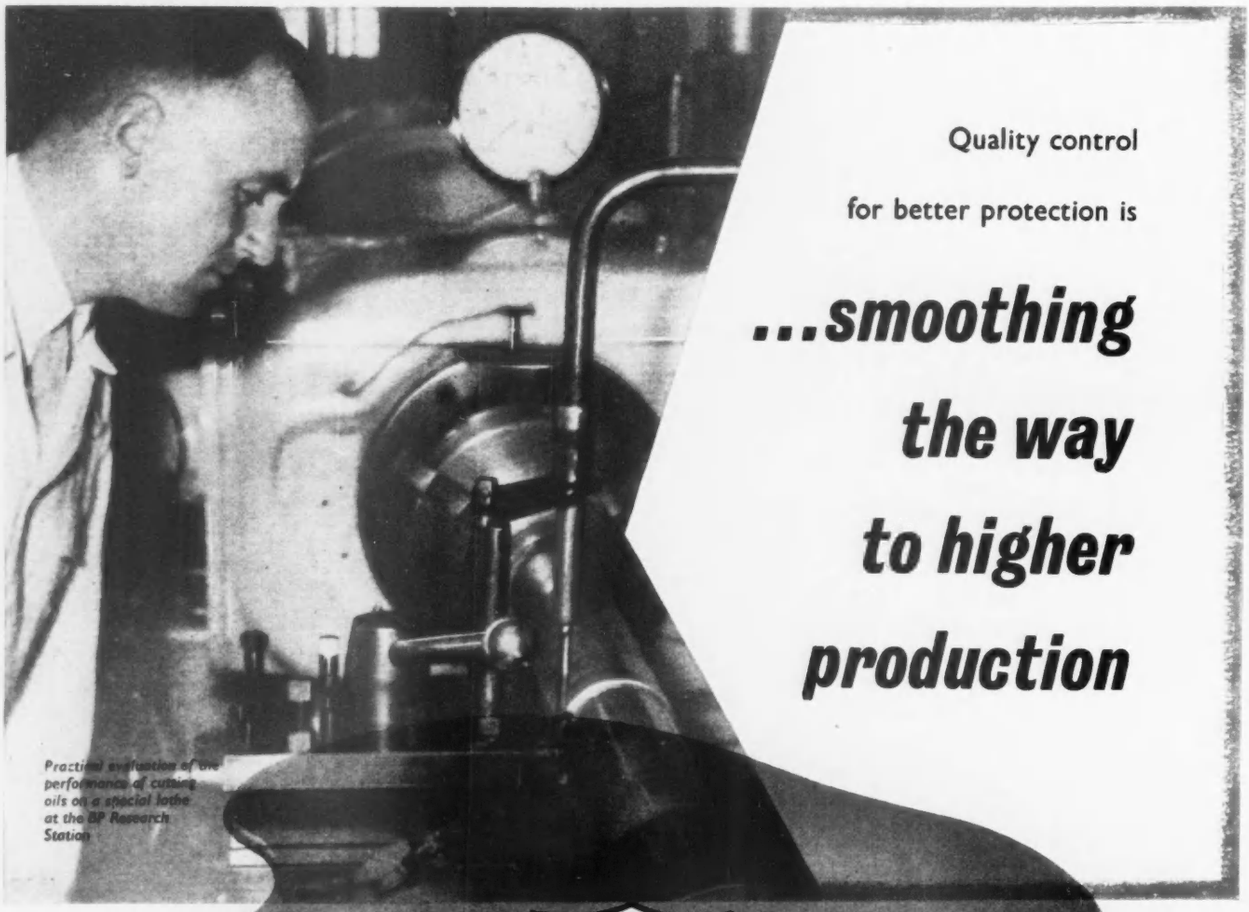

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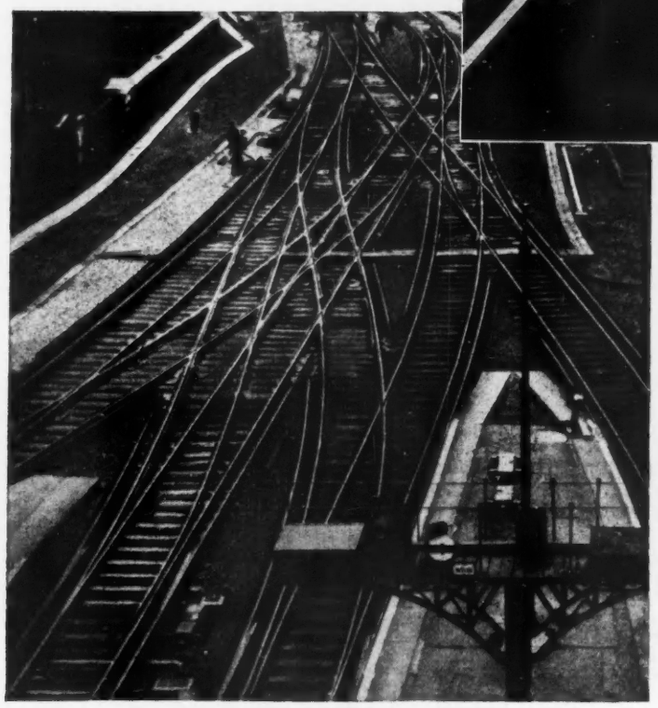

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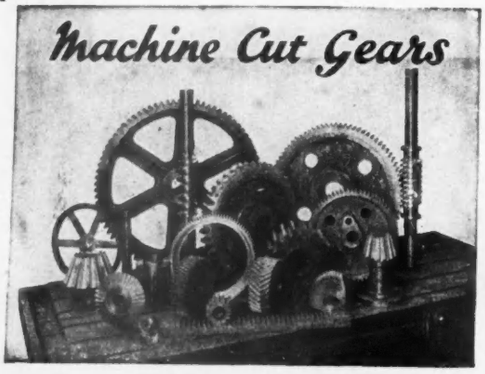

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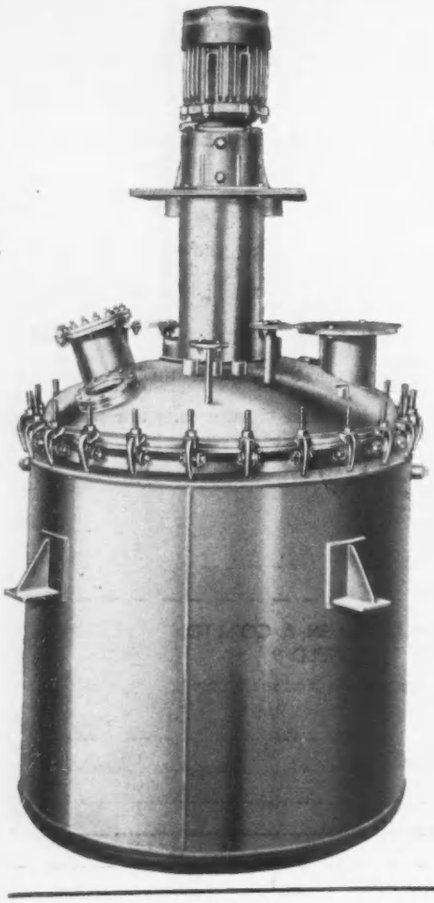

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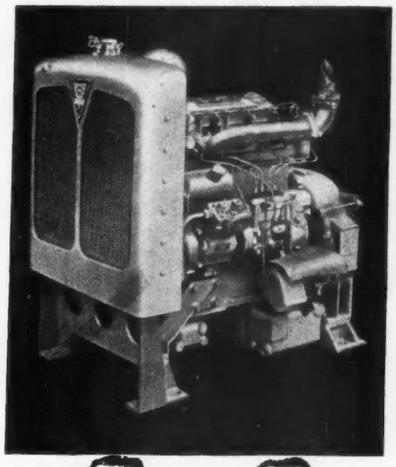

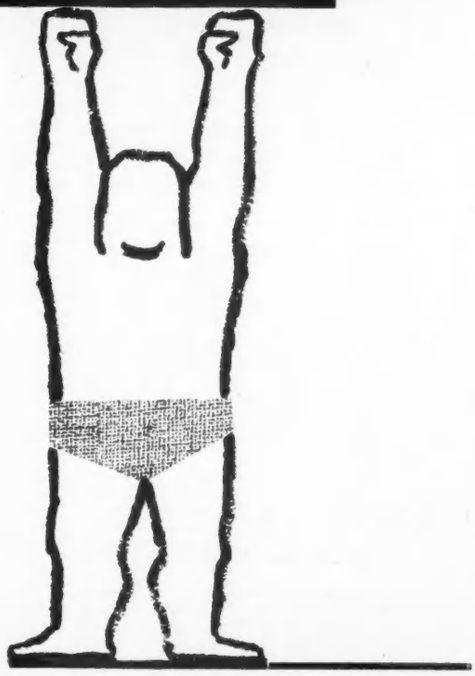

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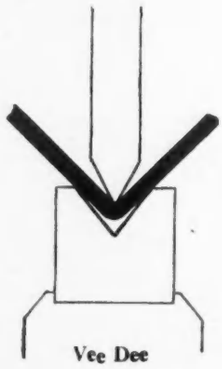
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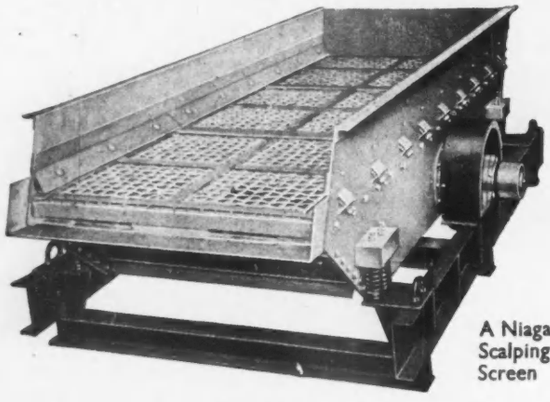
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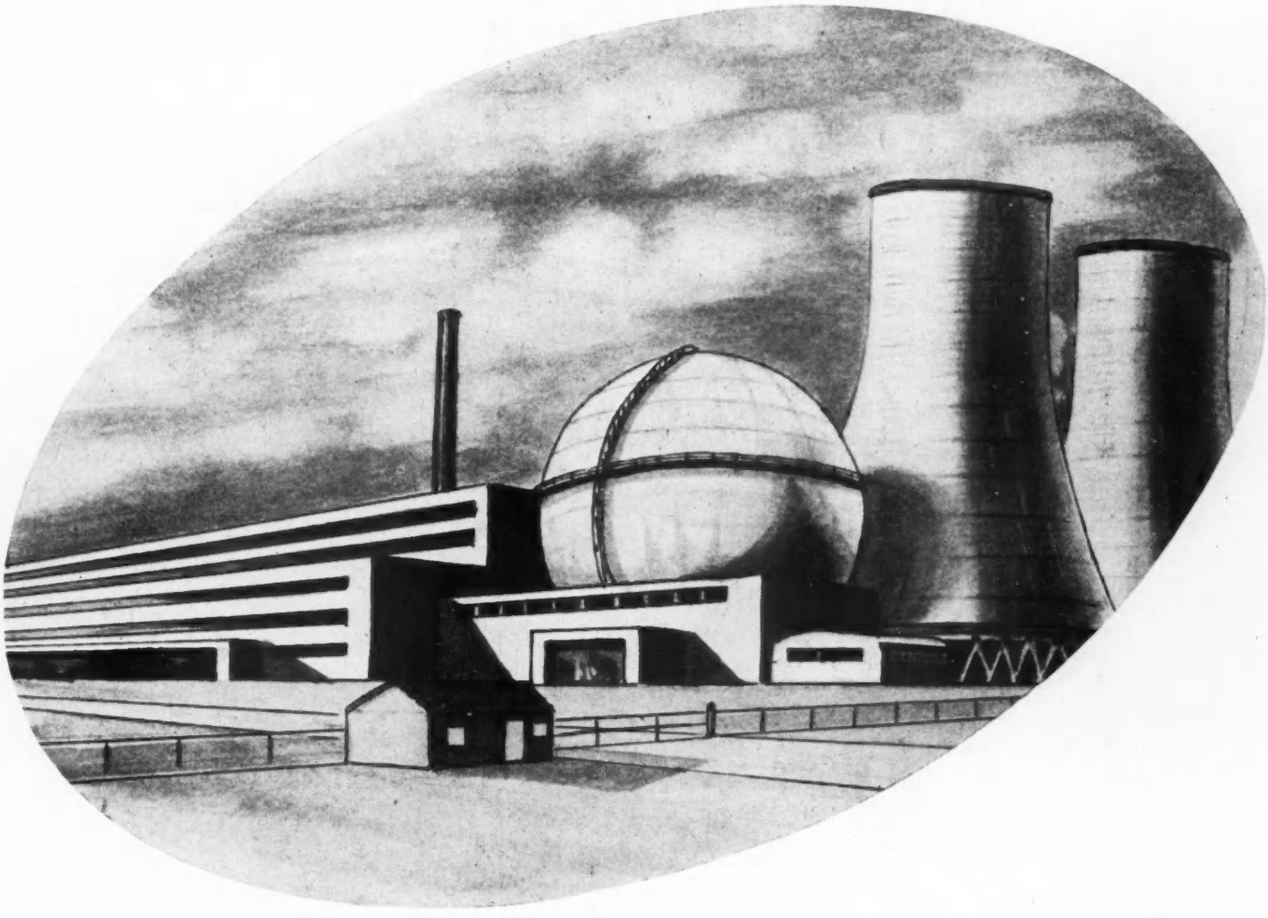

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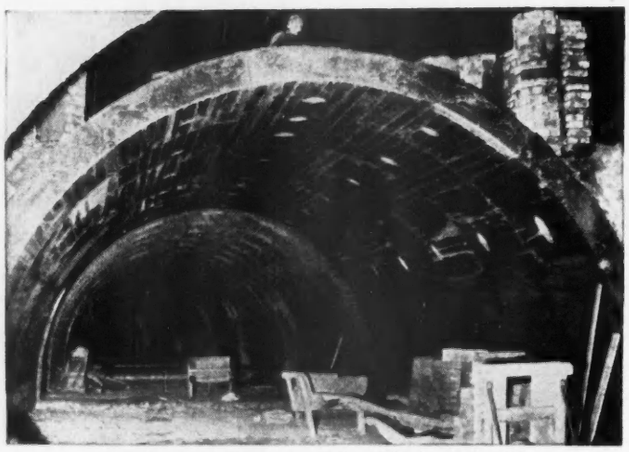

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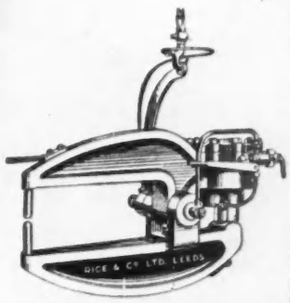

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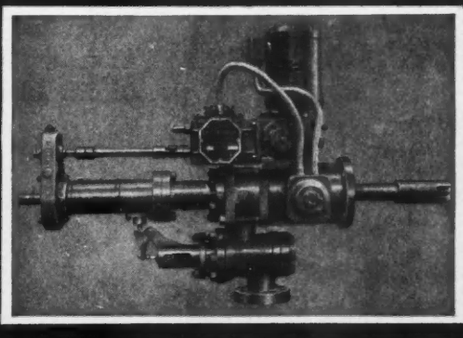

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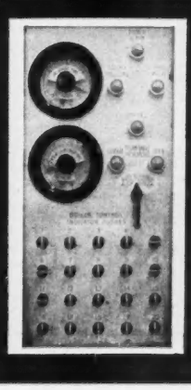

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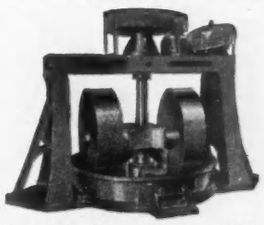

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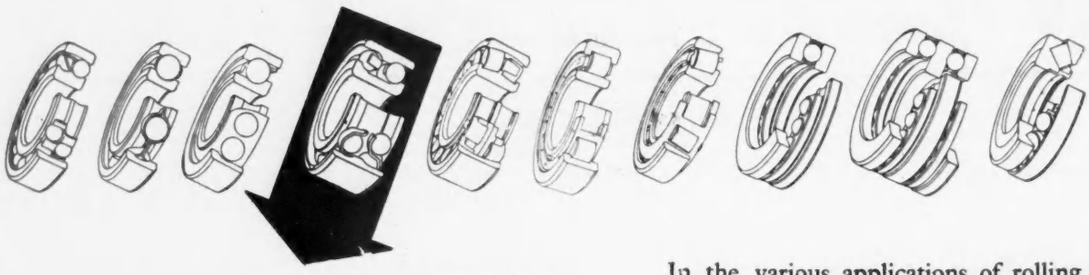

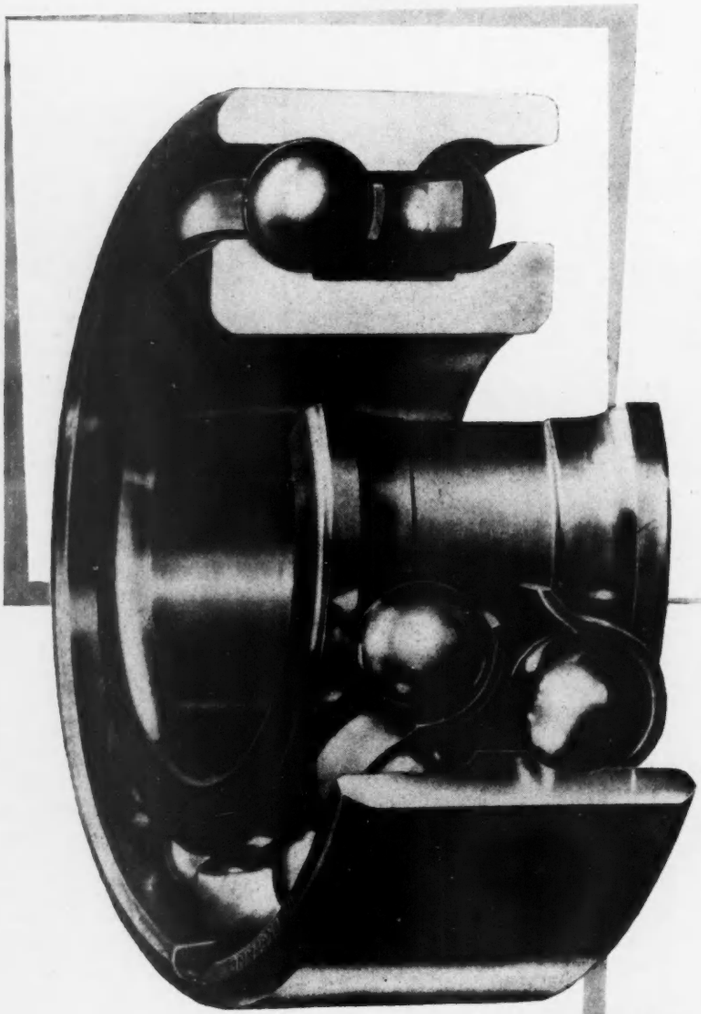

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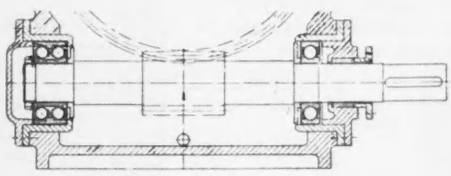

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THE ENGINEER

No. 5356 **SEPTEMBER 19, 1958** VOL. 206

LOOKING BACK ON GENEVA

The second United Nations conference on the peaceful uses of atomic energy is over, but the event was on too large a scale for us to see it yet in full perspective. We can say at once that in several ways it was a success. An enormous amount of material was presented, and this will give engineers and scientists all over the world a good deal to think about—if they have time to sort out what they want from the glut and study it. But as a conference we think, with Sir John Cockcroft and others, that the affair was rather too grand and ambitious, though perhaps if it had been organised on less spectacular lines the inducement to " show off " would have been smaller and we might therefore have been told less about what is going on. In a way it can be said that the nations made an exhibition of themselves in the less pleasant sense of the phrase. The struggle for political and technical prestige was perhaps too manifest for a conference of objective, even if not entirely pure, scientists. One might have expected that the " scientific " exhibition in the grounds of the Palais des Nations, which was intended to illustrate the papers read to the conference, would be on strictly disinterested lines, quite divorced from, say, the frankly commercial motives of the separate exhibition organised by the Geneva authorities. But the signing of a contract for the sale of a research reactor, to take an example, was staged at the Palais des Nations, not the Palais des Expositions, and salesmanship of this misplaced kind was displayed in several cases. We do not at all deplore the commercialisation of nuclear technology. On the contrary, we welcome it, and see good prospects of trade for this country in the new industry. Nevertheless, we felt some twinges of regret at Geneva when we found that the atmospheres in the scientific and the commercial exhibitions were so akin in this respect. No doubt there is a trace of the idealist left in us, perhaps even a secret admiration for the concept of an ivory-tower scientist.

Having spent a mentally exhausting fortnight at this huge international conference, we fully appreciate the relevance of a certain study that was preliminarily reported during the second half of the proceedings. A group that had been called upon to advise the director-general of the World Health Organisation then released an account of its findings on the " mental health aspects of the peaceful uses of atomic energy." Among these findings was one that atomic energy, for most people, remains threatening and mysterious, interpreted very often in magical rather than rational terms, and fraught with irrational fears and hopes. While, " with the low dosages of radiation to be encountered in the peaceful uses of atomic energy, the organic brain effects so far observed are of minor or no importance," the mental effects are still serious : for, " where exaggerated hopes have been aroused, there may be disappointment and disillusionment when nuclear installations do not prove feasible or do not produce at once a miracle .... The repercussions from eventual disappointment may be severe." This is true in its way, and some of the more optimistic projects of the first United Nations conference on " atoms for peace " have now been shown to be less promising than when they were first described. But the conclusions drawn from this emergence of technical difficulties are various. As we have remarked, the W.H.O. finds danger to the world's mental health, at least if there are too many and too drastic disappointments, and warns against the hostility that might be aroused if the higher standard of living promised with atomic power in underdeveloped countries does not materialise. Professor Perrin, who presided at Geneva, said in his opening address that only technically mature countries could benefit at present from nuclear energy, and that the underdeveloped countries should spend their time and money on evolving a conventional industrial basis first. Dr. Bhabha, on the other hand, argued that certain areas were already ripe for nuclear power, and he presented sound arguments to support his opinion in the case of India. We ourselves lean toward Dr. Bhabha's view, and Professor Perrin was gracious enough to concede it in his closing speech. As engineers, and, we hope, rational men, we do not suffer from what the W.H.O. study group describes as the universal feeling of man's punishment for presumption. Technical difficulties are only to be expected. They come, and some of them will be overcome. Many of them have already been overcome. Nuclear power is a reality, and if it is used in certain of the over-populated and under-equipped parts of the world there is hope that it will help to destroy just those magical and emotional modes of thought that make men subject to irrational frustration when miracles fail to occur.

While it is certainly desirable in the long term to secure the masses against frustration, in the shorter term it may be of greater importance to watch the mental processes of politicians. A question frequently put by lay inquirers at the conference was : " Why bother about fission reactors if, as Dr. Bhabha predicted in 1955, we shall be getting power from fusion in 1975 ? " Asked whether he would give a new estimate in the light of the results and speculations reported at the present conference, Dr. Bhabha replied " twenty years minus three," but he pointed out that it would take at least another decade after that to make fusion power a commercial proposition. Even so, the layman (or the politician) may think, is it not a waste of time struggling with fission when fossil fuels are still to be had, and for longer than twenty-seven years ? Part of the answer is that there is many a slip 'twixt the cup and the lip. A host of ingenious ideas has been presented, and laboratories are researching vigorously in at least three countries ; but so far the prospects are bright only on paper. And, as several physicists emphasised during the conference, the theory of plasma and

thermonuclear fusion reactions is full of serious gaps. While no one should dare to suggest that the work on fusion will be fruitless, we must still be wary of over-confidence : it is not certain that the work will be fruitful in the way that we expect and hope that it will. Fission power, on the other hand, is already with us, and adds greatly to the store of usable energy in the world. It may well prove that fission and fusion processes can be effectively compounded in certain cases, should fusion ever come under control. Fossil, fissile and fusile fuels are likely to remain complementary rather than mutually exclusive for as long as each of them lasts. Local conditions must determine which, or which combination, should be used at any given moment. In the meantime, we should certainly push forward with fission reactors, and it is to be hoped that those who hold the purse-strings will not be misled by the proportion of papers and exhibits at Geneva that dealt with fusion. If the second international conference on the peaceful use of atomic energy results in a misguided retardation of effort on fission reactors, then it may well have failed disastrously.

THE MONTREAL POWER CONFERENCE

Last week, the World Power Conference held one of its " sectional meetings " in Montreal. The theme of the conference was " economic trends in the production, transportation and utilisation of fuel and energy." The five days of technical discussions, visits and social functions were characteristically international in character, and were attended by over 1000 delegates. Not surprisingly, no major new developments were revealed, but the general trend of advance in the various technologies of fuel and power was well brought out. Hydro-electric engineering was heavily emphasised in relation to its real contribution to world resources of power, presumably because the host country, Canada, and, in particular, the province of Quebec, is characterised by extensive use of this particular natural resource, and also perhaps to attract delegates who would be attending the congress on large dams in New York immediately afterwards. The continuing world-wide increases in the consumption of electricity have caused a new phase in the utilisation of hydro-electric power. Several of the papers emphasised the role of water power in mixed, interconnected systems of electricity generation. In some countries where water power has met all the demand until recent years, resources are becoming exhausted. Thus increasing emphasis is being placed on concepts such as that of the overall development of a river catchment, rather than on one or two exceptionally favourable sites within the catchment, and of the changing functions of hydro-electric power stations in a growing power system, exemplified by the installation of sets to meet peak loads, and also the development of pumped storage. This last topic—pumped storage—was especially in emphasis at the conference, not only for the reasons already given, but also because of the value of pumped storage when combined with nuclear generation of power. It was especially interesting to hear discussion of the relative merits of two designs of reversible pump/turbines, on the one hand the newly developed Deriaz machine, developed in this country, which can be loosely described as a Francis turbine adapted so that the pitch of the runner blades can be varied, and, on the other hand, of the fixed-blade machine made in the United States for similar duty.

Operating experience with the first super-critical steam-turbine generating set, which is installed at the United States power station of Philo, was reported in one of the papers, and its problems were discussed together with related matters in the development of very large generating sets, a number of which have been designed and ordered. The Philo set has a rated net output of 110MW, and the overall results of nine months of its actual operation were given. It is considered to have proved itself sound in engineering design and construction, but does not give appreciably increased economy ; this result was expected, since the set was considered as a prototype for more efficient sets in the future, and the experience gained with it is being incorporated in larger sets. In particular the design of two 450MW sets for the same utility incorporates the proven features of the Philo set. The future plans of several countries in installing very large steam turbine generating sets were explained during the discussions on thermo-electric generation. Other topics which were prominent at that time included opinions on the merits of mixed gas and steam turbine cycles and of heat-electric generation.

The winning of the basic fuel—coal, oil, gas or " nuclear fuel "—received its share of deliberation, and there was considerable attention to " utilisation " under a variety of subject headings. There was also a group of papers on nuclear energy in spite of the conflict of dates between this conference and the one at Geneva. The general theme of the conference on " economic trends " is, of course, presupposed, by any discussion of purely engineering advances ; economy is an inherent factor of engineering design, so purely engineering matters were happily at home in this framework. In other matters, figures of costs and economic appraisals were given in papers and discussions. But the widest economic issues were not touched upon. By the " widest " issues we mean those problems—referred to at earlier World Power Conference meetings—of relating the economy of investment in power with other factors in a country's economic progress. Power is the keystone of economic growth, but it demands large capital investments ; other worthy investments may be starved of capital by its demands, or, alternatively, the rate of power consumption may not increase fast enough to promote other industries. Considerations such as those are basic to a balanced progression of economic and industrial activity, but they verge into political as well as technological spheres. The World Power Conference is noteworthy for the generality of its theme, and for the fact that it brings together many specialists in differing disciplines of thought, and in different countries. But evidently, in the opinions of the authors and speakers at the Montreal meeting, these more general economic problems were somewhat beyond the scope of the conference, for no attempt was made to interpret " economic trends " in this manner.

1962

According to present plans, Britain in 1962 will have an army of 165,000 volunteers supported by a small Tactical Air Force ; a deterrent consisting of unrevealed numbers of V-bombers and megaton and nuclear bombs and ballistic rockets ; and an active fleet of four carriers, three cruisers and a number of destroyers, fast frigates, minesweepers and submarines—including one submarine with a nuclear power plant for propulsion. It may be that a few of the rockets will be of a new type—the " Blue Streak "—with a range of 2000 to 3000 miles, launched from underground and capable of being fired at short notice. But in the main our ballistic rocket defence will consist of the American-designed " Thor " fired from above ground after considerable preparation and with a range only sufficient to reach Moscow from launching sites in East Anglia. These weapons and forces are being built up under our five-year defence plan which aims at preventing a major war rather than preparing to wage it.

It is a popular plan. The British people are happy to see the end of National Service. It is still more pleasing not to have to think about preparations for war. Despite the urgent demands for money for the social services, there seems to be a sublime belief that the Chancellor and future Chancellors will each year provide the money for " an appreciable element of nuclear deterrent power." What constitutes " an appreciable element " can be known only to the Government. For the deterrent must be built up in secret. It may well mean 500 V-bombers and 100 megaton bombs ; or it may mean no more than fifty bombers and ten bombs. When complaints are made that our active fleet is far too small, we are informed that the Royal Navy will be fighting as one member of the N.A.T.O. team—a satisfying answer, perhaps, in view of the strength of the United States Navy. But it certainly suggests that Chancellors will remind Defence Ministers that " the free world is mainly dependent for its protection on the nuclear capacity of the United States," and insist that a token force of bombers and bombs is in fact " an appreciable element."

In a word, the nation would do well to question a defence policy which is quite clearly based on economy and on reliance on our Allies rather than on our own and N.A.T.O.'s defence requirements. Russia's aim appears to be to dominate the uncommitted and underdeveloped countries by subversion and by giving them all the credit they require. She cannot want a major war ; and least of all to fight it with nuclear weapons. But while frightening the West with her readiness for nuclear war, she has built up an enormous army, navy and air force in case her subversive policy should involve her in major hostilities. It may well be she intends to fight with conventional weapons, confident that no Western Government will deliberately resort to the ultimate deterrent. The American people, on the other hand, are taught to be prepared for nuclear war on the assumption that the United States' retaliatory power and defences will enable the Western Nations to survive provided their sea communications are safe. Both the Soviets and the Americans thus realise the vital importance of their navies. But Britain, once the world's greatest naval power, now apparently prefers to add a token amount to an already adequate deterrent in the hope of preventing war rather than to build up adequate sea power. Apparently in the belief that half-a-dozen thermonuclear missiles would immobilise this country in a very short time a defence policy has been formulated which will do little to assist in maintaining peace or in fighting a war. Surely Britain should aim at having a navy of a sufficient number of the right types of ships and aircraft to prevent a local war spreading and to be of the greatest assistance to N.A.T.O. if it does ?

EMBERS OF CONTROVERSY

The news that an application has been made to extend the Bankside power station in London, just across the Thames from St. Paul's Cathedral, may stir the embers of an old controversy. Just over eleven years ago the old Bankside power station on this site came to the end of its useful life and the City of London Electric Lighting Company thereupon sought to build a new power station there. But under the County of London Plan the area, once the old power station had become disused, was scheduled to become an office and residential neighbourhood. The London County Council therefore opposed the adoption of the Company's proposal. Then the Government stepped in. What we termed at the time " the autocratic powers given to the Minister of Town and Country Planning " enabled him to sanction the project and over-rule the L.C.C. veto. Thus was the controversy sparked off. For many people—we were among them—regarded the centre of a great city as a very inappropriate place for a power station. Those who opposed the project had the support of the Royal Fine Art Commission. That Commission, though it did approve the design of the building, was never consulted about the suitability of the site. It did state, however, to the Town Planning Committee of the L.C.C. that it considered the site " inappropriate for a very large public utility structure." Looking back now upon the controversy it seems to us that the Government acted almost in a panic. It was, of course, quite correct for the Company to propose to build a new power station on the site. For as compared with any other site power could be generated there sooner than anywhere else and, because transmission lines would have been required from any site outside the central area, at less cost. It was for the L.C.C. to express the community view that rather than continue to have a power station on the site it would willingly pay more for current and wait longer for it. But what weighed with the Government against such factors, appears to have been the critical relationship it foresaw developing between supply and demand for electricity in the central area. In order to prevent the possibility of demand exceeding supply in the central area over the period of twelve months or so by which the time to build a power station at, for example, Rotherhithe, would have exceeded that of building one at Bankside the Government imposed upon London the necessity of putting up with a power station on the site for at least thirty or forty years. For if the power station is only to be extended to its full size under the application now being made it can be reasonably assumed that the plant will not have exceeded its useful life until 1980 or later. Not till then will it be worth while to re-open the controversy.

The Engineer— 100 Years Ago (SEPTEMBER 17, 1858)

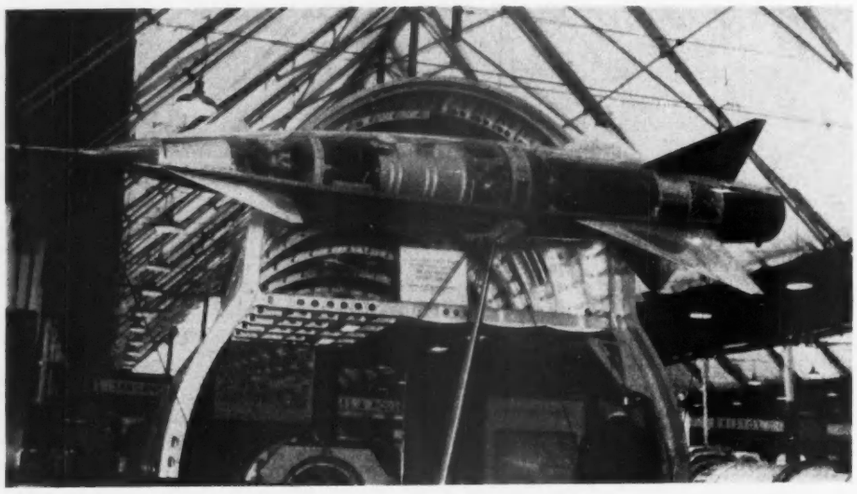
NOTES ON AMERICAN ENGINEERING."

" Steamship-building which, under the impulse of Californian trade, was so flourishing in New York, in 1852, and the succeeding two or three years, is now almost entirely suspended. In August of last year, thirty-seven ocean steam ships (besides 759 sailing vessels) were lying idle in the port of New York. Since then, two or three steamers have been built for foreign countries, but very few, if any, for the United States. Two steamers, each of 2,500 tons, and which cost, originally, £60,000 each, were sold last spring for £9,200 *for both*, not because they were worn out, but because they would not pay. They have been re-sold for £30,000, since the discovery of the gold mines in New Caledonia, and one of them, the Hermann, lately started for that region, via Cape Horn, with 600 passengers. Such depressing circumstances have not aided the progress of improvement in marine engineering . . . .

" Some large railways works are in construction, although these at the present time are in a languishing condition. The Hoosie Tunnel, to be, if ever finished, 4½ miles in length, is progressing very slowly. It cannot have more than two shafts, these being several hundred feet in depth. The longest tunnel yet made in America is 4,240 feet, and this has no shaft. The rate of progress in its construction averaged about 300 feet yearly from each end. A tunnel of two miles length at Cincinnati has been in construction for three or four years. The entire length of tunnelling finished in the United States is a little more than eleven miles . . . .

" A furnace has been built in Pennsylvania, in which the blast is heated by a separate fire, and it is believed that, instead of more coal being consumed, less is required, from not interfering with the gases in the trunnel head. A better quality of iron is believed to be afforded also.

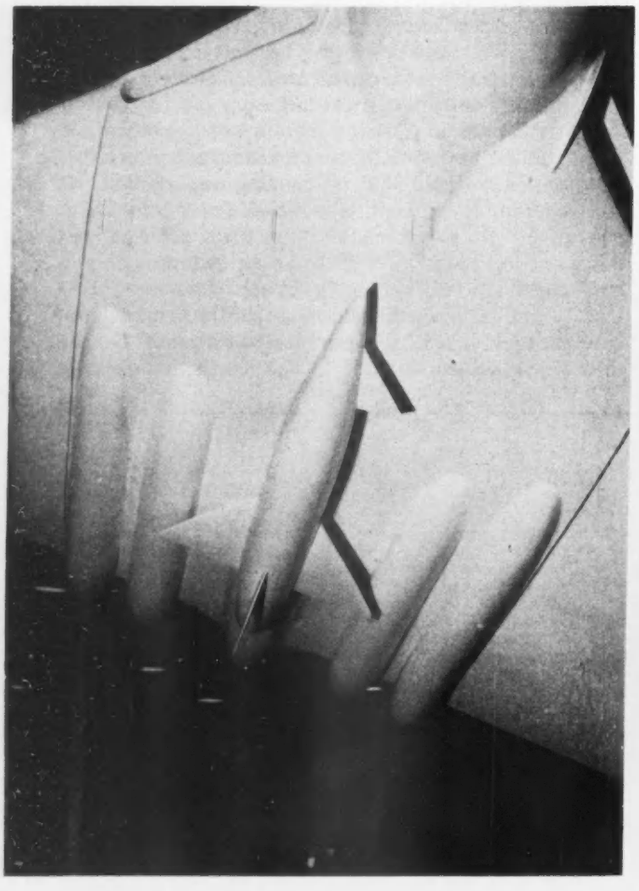
Air-to-Surface Missile in Model Form



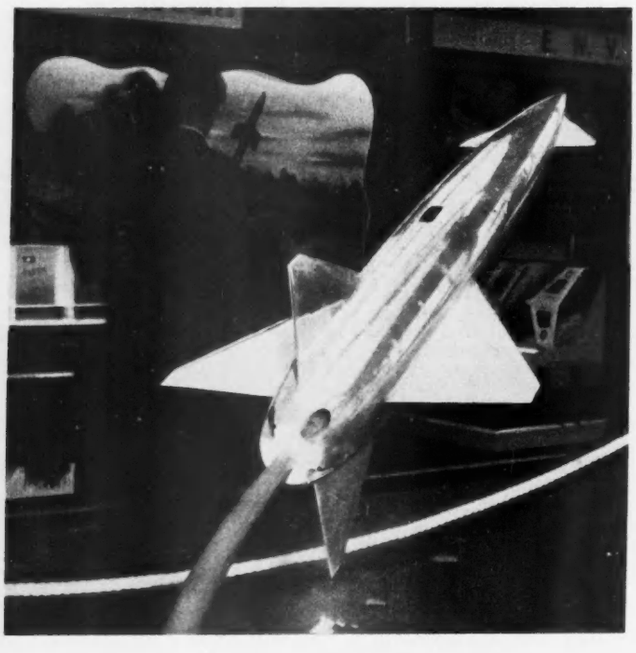
These models of the Avro powered guided bomb allow a rather more detailed study than would otherwise be possible. The models are, ABOVE, a large powered control test vehicle, BELOW RIGHT, a ground-launched aerodynamic test round and, BELOW LEFT, a small-scale representation of missile and carrier together.

From the models various conclusions can be drawn : prominent is the fact that the wing section is smoothly curved, with a rounded leading edge, showing clearly that the leading edge is subsonic and the forward speed therefore not more than Mach 2 (the included angle appears to be very close to 60 deg.). In contrast, the fore plane of the control test vehicle has a double wedge section, although the plan-form is very close to that of the wings ; the line of maximum thickness is also swept, but this is probably a structural necessity resulting from the choice of plan-form. The smaller model does not share this feature ; on it both fore and main planes have classical rather than conical camber. The model attached to the " Vulcan " is again different ; here the tips of the fore plane are cut away at about 45 deg., and the outer parts of the wings given marked anhedral. This modification is fairly easy to understand, since both rolling and yawing control surfaces have very small moment arms with which to counter the great stability of the swept plan-form.

There are on the largest model two nozzles, one above the other, which has led to speculation that the de Havilland " Double Spectre " is the full-scale power plant. This may be ruled out, however, since the engine builders of the Hawker Siddeley Group rejected the technique of obtaining a thrust variable over wide limits by the use of two chambers because the uncontrolled change of thrust at lighting and extinction of the second chamber could not be followed by the variable chamber. The models do not give any indication of the method of guidance employed. Guidance for the stand-off bombardment role presents a severe problem in the case of a missile which does not possess extreme performance, since the obvious choice of active radar exposes the weapon to prolonged counter-measures. Command guidance, while simple and relatively reliable in a difficult tactical situation, may be discarded when it is seen that this vehicle is built to be economical in a cruise rather than exceedingly fast, and will obviously fly beyond the range of visual or infra-red surveillance. Passive homing is a more probable solution ; since infra-red decoys are comparatively easy to deploy, radar techniques are the most likely answer, and certainly the nose cone of this weapon is more likely to transmit electro-magnetic than optical wavebands. However, there is very little evidence to support the belief that passive radar techniques have, in this country, advanced to such a stage as to be able to navigate an unmanned aircraft. The final possibility is, of course, that the vehicle is entirely self-contained and flies itself to a point defined with reference to its place and direction of launching ; since this means that the inaccuracies of the aircraft navigation are enhanced this method seems unattractive



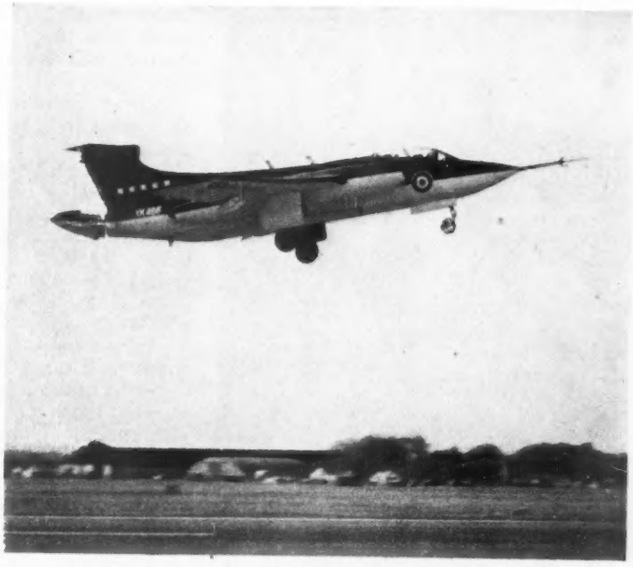
It may be of interest to record that the UPPER illustration also shows part of the hull of the sixth production Armstrong-Whitworth " Argosy " freighter-coach aircraft. The section exhibited had seats in place at one end and, at the other, the seats folded against the side walls to make room for freight, including a Rolls-Royce " Dart " engine, four of which will power the actual machine. The flight deck, which is above the cabin, or hold, to allow loading from either nose or tail, was also part of this section.



S.B.A.C. Display

No. III—(*Concluded from page* 366, *September* 12)

The 1958 Flying Display and Exhibition of the Society of British Aircraft Constructors took place two weeks ago at Farnborough; the Royal Navy and Royal Air Force took part in the programme. The Blackburn "N.A. 39" shown here was seen in flight only. We give below some impressions of the aircraft and missile engineering seen on static exhibition.

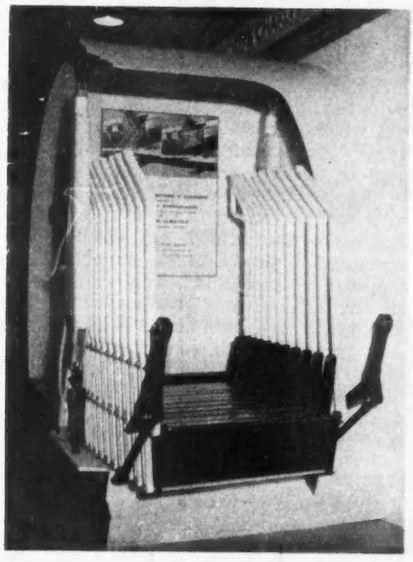


A DEVICE capable of effecting major savings in inspection effort was displayed on the stand of Bristol Aircraft, Ltd. Intended to detect cracks emanating from holes in metal, it takes the form of a probe which is inserted in the hole. The metal around the hole then becomes the secondary coil of a transformer, the primary being on the probe: a crack will alter the length of the eddy current path and change the impedance of the primary. The instrument is calibrated on a round hole and can then carry out rapid checks on similar holes ; a double-coil probe is claimed to eliminate the effect of differing sizes within the tolerance band. As our illustration shows, the power unit and detector is compact and portable. An instrument employing similar principles, but using paper tape presentation to show even deposits on the wall of a tube, was shown by Sperry Gyroscope Company, Ltd., under the title "Introview," having been originated by I.C.I., Ltd.

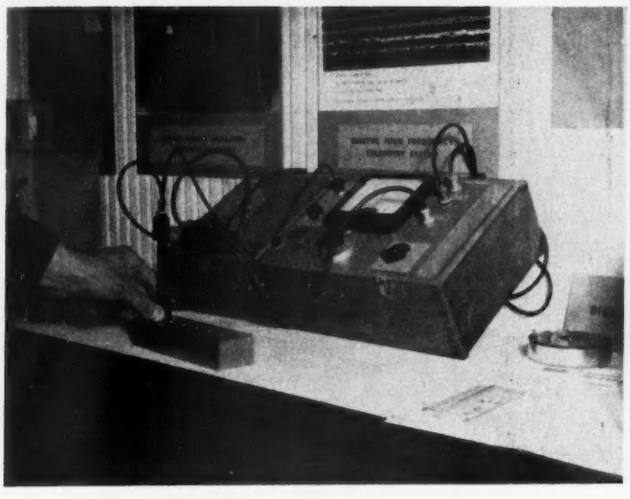
Marston Excelsior, Ltd., drew attention to their "Portolite" tanks, which are collapsible bags for the storage or transport of liquids. The bags are made of two layers of fabric, woven from nylon or other suitable material, bonded and rendered impermeable with a rubber-like material, chosen to suit the liquid involved. The tanks are either black or white, the latter being best suited for hot climates. The particular application for which these tanks are demanded is one-way haulage of oil, such as takes place in great volumes in, say, South America. An 800-gallon bag has been made and tested on a 5-ton truck, but no details of its performance are at present available. It is expected that the bag tanks will be developed to allow less than a full load of liquid to be carried.

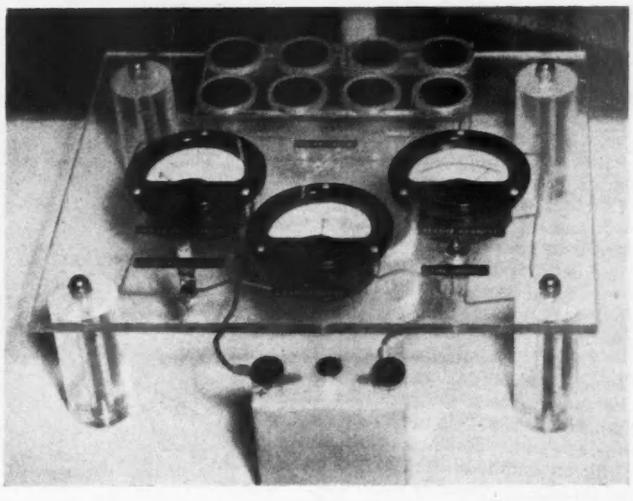
On the stand of J. Stone and Co. there was shown the Strabor "Airscalator." This is a collapsible stairway which allows an aircraft to be less dependent on ground support, which may give a saving in turn-round time. It can be envisaged that if two entrances on opposite sides had such stairs, and both were between the nose and main landing gears, these stairs would also meet the requirement for a means of exit in an emergency. One important feature of the stairway is that it does not obstruct the doorway either when it is partly or fully retracted. Our illustration shows it almost completely closed : it is extended by two hydraulic jacks until the treads are level and the short inclined segments of handrail lie in line. The components are principally castings in magnesium "Elektron C."

There appears to be a tendency for the British manufacturers of disc brakes to favour discs driven at the inside, despite the fact that the distribution of components radially results in less disc area with this design. An example of the potentialities of driving the disc at its outer edge is displayed by the Goodyear Tyre and Rubber Company and illustrated overleaf. Perhaps the most interesting detail of this design is that, in

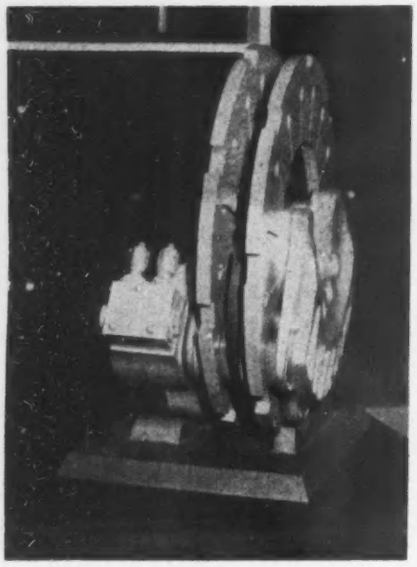


A collapsible stairway that does not obstruct the doorway of the aircraft





(Left) This instrument is able to detect any cracks radiating from a hole by their increasing the eddy current path length. (Right) Eight "Nat-Fab" solar cells assembled in a demonstration circuit



The double-disc brake for the " Herald "

order to raise the limitation on the rate of heat transfer radially outwards set by loss of symmetry of the disc, it is slotted to reduce compression stresses at the inside.

A novel feature of the stand of Chloride Batteries, Ltd., Clifton Junction, Manchester, was a demonstration of solar-activated cells. These cells, activated by electric light, were used to recharge small orthodox batteries. In this manner the variable output of the solar cell, which is dependent upon the intensity of the incident light, may be converted to a steady usable supply by the orthodox accumulator. This is the combination used in space satellites, where radio transmitters have been kept working for very long periods—much longer in fact than would have been possible without taking advantage of solar energy. The cells were of United States origin and on loan for the exhibition.

Electrical Instruments and Components

An instrument that should be of considerable interest to the trials staffs of Service establishments and proving grounds is the electronic velocity analyser (" EVA "), developed and shown by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex. As its name suggests, it provides a means of obtaining a continuous record of velocity ; it can be applied to road vehicles, aircraft, projectiles and missiles with speeds up to 2050 m.p.h., as explained below.

Briefly, " EVA " is a miniature portable Doppler radar set operating in the X-band to provide an accurate and continuous record of velocity performance of moving objects within a wide speed range. The basic equipment covers speeds between 2 and 80 m.p.h. (3ft to 114ft per second). However, by the addition of stable local oscillators (working up to 50 kc/s, for example) and an amplifier and detector chassis, the equipment can scan any speed range of 80 m.p.h. (115ft per second) up to 2050 m.p.h. (3000ft per second).

Range requirements are likely to vary from a few hundred yards for vehicle testing, to much greater distances for rockets and guided missiles. To meet such requirements, the analyser is designed as a basic equipment with an output of 50mW and beam widths of 20 deg. horizontally and 6 deg. vertically, giving an effective range performance of about 500ft on a target presenting an effective radar reflecting area of one-third of a square metre. The range is extended to 1100ft by the inclusion of a superheterodyne receiver and this can be further extended to 3500ft by increasing the transmitter output power to 5W. Depending on the target size, even greater ranges (of the order of 3 to 9 miles), can be achieved by using valves of still higher powers and by increasing the aerial gain. The accuracy is specified as $\pm$1ft per second.

The record is obtained on moving " Teledeltos " paper and gives a continuous graphical representation of events which are recorded against a reference of calibration pips which occur every one-tenth of a second. The recording paper is available in various widths and can be run at varying speeds. " Eva " will record instantaneous changes in velocity which are often undetectable by other means. Additional recording arms may be fitted if desired.

With certain targets such as aircraft, the received signal is modulated by propellers or turbine rotors ; this modulation appears as a time variation in indicated speed and with many instruments this effect prevents the measurements of velocity being recorded. With " Eva " however, the undesirable interference is immediately apparent and in assessing these plots the regions of interference can be ignored and a true measurement of velocity obtained.

The equipment, as illustrated below, consists of a transmitter and receiver in a portable case (left) measuring 1ft 6in by 1ft 3in by 2ft 4in, and an analyser (right), also in a portable case, 1ft 5in by 2ft by 1ft 9in. A multi-core cable connects the transmitter/receiver and the analyser. The equipment is suitable for a.c. power supplies of 230V, 50 c/s and the power consumption is 200W.

As we mentioned in last week's article, the second main trend discernible on the electronics side at Farnborough was that of reducing size and weight of airborne apparatus, at the same time increasing its resistance to mechanical damage. These attributes of compactness and robustness are not usually compatible as design requirements, but transistors and printed circuits are exceptional in allowing the designer the best of both worlds. The great variety of equipment on show at Farnborough makes it difficult to particularise but good examples were to be seen on the stand of Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2. This company showed, *inter alia*, four new airborne radio equipments incorporating transistors and printed circuits.

The first of these is a comprehensive v.h.f./i.l.s./v.o.r. airborne communication and navigation equipment. Its main component parts are : an " ST23 " transmitter providing 360 channels, 50 kc/s channel spacing in the band 118–135·95 Mc/s, 20W telephony ; an " ST23 " receiver of 560 channels, 50 kc/s channel spacing in the band, 108–135·95 Mc/s with all spurious responses at least 90 dB down ; an " SR.34 " v.o.r./i.l.s. localiser receiver, comprising a receiver and instrument drive unit, the receiver being identical to and inter-changeable with the " SR.23," for 100 channels, 100 kc/s channel spacing, in the band 108–117·9 Mc/s, 50 kc/s spacing incorporated and available when required ; an " SR.35 " glide path receiver, for twenty channels in the band 329·3 to 335 Mc/s ; and an " SR.36 " 75 Mc/s marker superheterodyne receiver.

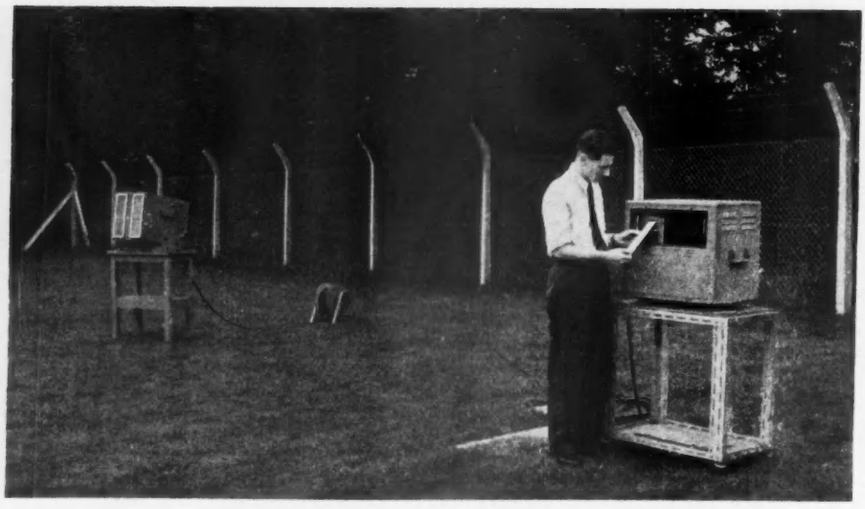
The second equipment is an " SA.10 " transistorised audio control and intercommunication airborne set, designed for extreme reliability, providing intercommunication between crew members, selection and monitoring of the output of any three of fourteen radio receivers, selection of any one of five radio transmitters and allowing limited facilities available during emergency conditions.

Both the above equipments, we learn, have been specified by British European Airways for the " Vanguard " and " Comet " fleets.

The third equipment was developed for the Ministry of Supply ; it is a frequency-modulated, sub-miniature radio altimeter incorporating transistors. It operates in the frequency band 4000 Mc/s and gives a height indication of 0ft to 500ft or 0ft to 5000ft, with a specified lower limit of 2ft. It is a sub-miniature version of the " STR.30B " set.

Lastly, there was a " transistorised " four-channel, m.f., airborne radio teleprinter, with a frequency range of 90 to 135 kc/s and a power consumption of 1½W at 115V, 400 c/s, single phase. The teleprinter was specially developed for airborne use by Creed and Co., Ltd., an associated company of S.T.C. The teleprinter is capable of operating at 100 words per minute, and the total weight of receiver and teleprinter is 45 lb.

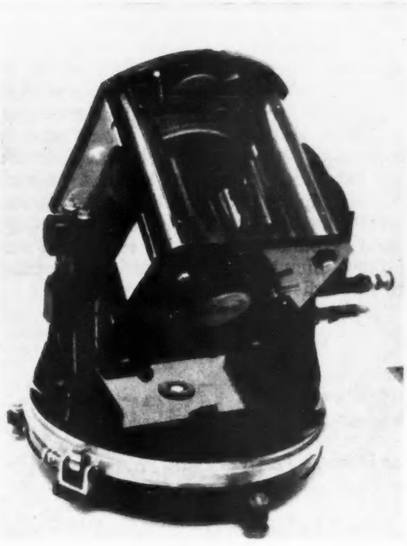
British-made, self-contained gyro test sets (apart from custom-built equipments) are a comparative rarity. It was therefore interest-



Electronic velocity analyser. Velocity of a vehicle is measured continuously by the transmitter/receiver on the left and a paper tape record is produced by the instrument on the right

ing to see two such testers which are commercially available, on display by Graseby Instruments, Ltd., Kingston By-Pass Road, Tolworth, Middlesex.

One of these instruments, the " G.I.390 " universal gyro tester (illustrated here) consists



Prototype universal gyro tester with servo-driven gimbals

of a substantial gimbal supported in a cage capable of being rotated around both horizontal and vertical pivot axes, the gimbal axis being perpendicular to the horizontal axis. All three axes are fitted with fine adjustments and graduated circles divided on glass and reading to one minute of arc by means of microscopes. In addition to the hand fine adjustment, which can be disengaged, the gimbal axis is fitted with a two-phase a.c. servo motor and 60 : 1 friction reduction gear, so that, in conjunction with the gyro and a suitable amplifier, it can be used to form a single-axis stabilised platform which can be swivelled into any attitude.

The test set is intended for all kinds of test on one- and two-degree-of-freedom gyros such as those used for inertial navigation purposes. Two main methods are used when evaluating the unbalance or measuring the wander rate of such gyros, namely, the closed-loop and the " servoed " gimbal methods. In the closed-loop method of measurement, the output from the gyro take-off is amplified, phase-sensitive-rectified if required, and fed back to the gimbal torque motor in the correct sense to " servo " the take-off to the null position. Under these conditions the circuit functions as a closed-loop servo mechanism and a record of the current flowing through the torque motor provides a measure of the torque required to hold the take-off at null in the presence of unbalance torques acting on the gimbal. In the " servoed " gimbal test, an accurately divided circle is fitted to the gimbal and the times taken for the gimbal to rotate through successive equal angular intervals are measured, the rates of rotation are computed, the appropriate components of earth's rotation rate are subtracted and the residues are taken as a measure of the wander rate of the gyro.

Because of its design, the " G.I.390 " gyro tester can be used, without stopping or remounting the gyro, as a three-axis precision dividing head for closed-loop tests ; alternatively, by using the servo control of the gimbal it can be used to study the performance of the gyro whilst the latter is actually stabilising a platform. When used for either test all three axes have 360 deg. freedom of movement.

It follows that, at one mounting and one switch-on, a gyro can be subjected to all the following six tests :—

(1) The gimbal torque motors can be calibrated either against earth's turning rate or by direct measurement of the precession rate produced.

(2) A six-position balanced check can be carried out by either the closed-loop or the servoed gimbal method.

(3) The wander rate can be measured in any attitude.

(4) The transfer function (ratio of input to output axis movement) of a single axis rate integrating gyro can be measured by rotating the input axis through an accurately known angle.

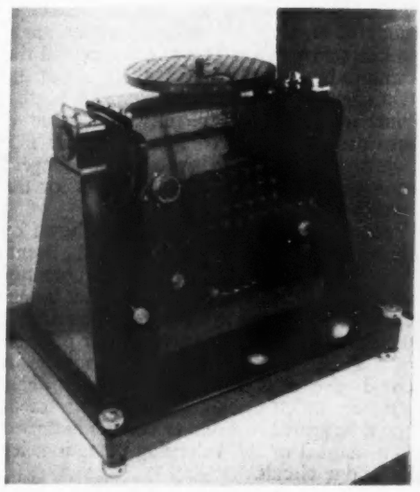
(5) The alignment of the input axis or the spin axis can be checked by rotating the gyro through a known angle around the spin axis.

(6) Using the rig as a precision dividing head, the rate threshold of the gyro or the gimbal bearing friction level can be estimated, either by observing the smallest component of earth's rotation which the gyro can detect or by observing, on closed-loop test, the apparent change in steady wander rate after the input axis has been rotated through an input angle of the order of one or two minutes of arc.

To facilitate automation of the servoed gimbal test, the gimbal circle is fitted with a photo-electric read-out device in addition to the reading microscope. This device, in conjunction with a suitable timer, enables the performance figures to be recorded directly on an electric typewriter. The accuracy of the glass scale is five seconds of arc anywhere over the circle and to enable full advantage to be taken of this accuracy, the photo-electric device takes simultaneous readings at opposite ends of a diameter.

Furthermore, the " GI.390 " tester can be fitted with an auxiliary a.c. take-off between the gimbal and the frame. Then, by connecting the auxiliary take-off to an amplifier, a phase-sensitive rectifier and a wide chart recorder and by passing through the gyro torque motor an unvarying current of such a sign and magnitude as exactly to cancel earth's rotation plus the average wander rate, the tester can be used to obtain a continuous record of the angular deviations of the servoed platform from its mean position.

The other instrument was a " G.I.657," a prototype polar axis gyro tester, as illustrated. It was designed primarily for carrying out the " tumbling test " originated by the instrumentation laboratory of the Massachusetts Institute of Technology. In this test a motor-driven turntable is set up with its axis accurately parallel to the earth's axis of rotation and the gyro is mounted on the turntable with its input axis perpendicular to the turntable axis (spin axis or output axis parallel to turntable axis for a single-degree-of-freedom gyro and spin axis parallel to turntable axis for a two-degree-of-freedom gyro). Under these conditions neither earth's

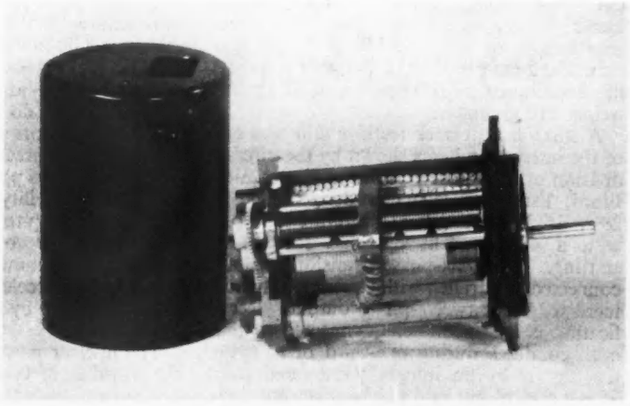


Prototype polar axis gyro test table

rotation nor rotation of the turntable have any component around the input axis of the gyro which then behaves as though the gravity vector were rotating around the gyro in a cone of semi-angle 90 deg. latitude. The test accordingly provides a very ready means of determining the magnitude and direction of mass unbalance and spring restraint torques acting on the gyro gimbal and experience suggests that it is useful as a method of checking the consistency and serviceability of the gyro in a wide variety of attitudes.

The method of measurement of the unbalance torques acting on the gyro gimbal is the so-called closed-loop method referred to above.

The " G.I.657 " table is designed to take single- or two-degree-of-freedom gyros up to 30 lb in weight or 6–8in cube overall. The table drive is by a reversible synchronous induction motor from 230V 50 c/s single-phase mains (so that it can readily be synchronised with a mains driven electrical recorder) through a three-speed gearbox giving ratios



Precision potentiometer with rating of 0·5W, effective length of track 157in, effective angle 50×360 deg., linear accuracy 0·008 per cent

of ±earth's rate (±15 deg. per hour), ±10 × earth's rate (±150 deg. per hour) and ±40 × earth's rate (±600 deg. per hour) together with a neutral position. Electrical connections to the gyro are through 24 low-noise sliprings : there is also a compressed air supply to the table. Auxiliary contacts can be fitted to indicate the angular position of the table.

Alignment of the table axis parallel to earth's axis can be done by direct sighting on

the pole star, using an angular telescope mounted on the table, or the elevation angle can be set by means of a clinometer and the azimuth by optical means making use of the two alignment pads on the trunnion bosses. Fine adjustment of the elevation angle is provided by the levelling screws and fine adjustment in azimuth is provided by tangent screws acting on one of the sockets for the levelling screws.

Among the smaller components shown by the Sperry Gyroscope Company, Ltd., Brentford, Middlesex, was a precision potentiometer, as illustrated on page 441. This potentiometer is designed to facilitate precise voltage division proportional to the angular position of a shaft. Fed with a constant voltage, it could give a signal proportional to shaft rotation in an analogue computer ; or it could be geared to a dial or counter and used in a manual or self-balancing potentiometer or bridge circuit.

The rotating mandrel is helically wound with fifty turns of silver palladium wire specially tested for uniformity. The gold alloy wiper is spring loaded radially towards the wire on the mandrel, and all contacts are tarnish free; it is carried along the mandrel on slides by a lead screw geared to the mandrel and parallel to its axis. The slides and lead screw are mounted on a balanced frame pivoted about the axis of the mandrel and spring loaded against a cam which advances the wiper along the wire by a few degrees. The initial shape of the cam is that required to compensate for the load on the potentiometer as specified by the customer. Adjustments are made on test to correct for manufacturing errors including non-uniformity of the wire. The standard cam is for a load of 250 kΩ and zero input impedance, but other combinations can be corrected by suitable cams. For use in bridge circuits, an initially straight cam can be provided to correct for manufacturing errors only.

The main particulars of the potentiometer are : linear accuracy with specified load (rating 0·5W) 0·008 per cent including error attributable to end connections ; resistance up to 1000 ohms with tolerance of ±5 per cent ; effective angle of resistance 18,000 deg. (50 revolutions) ; ratio of load/potentiometer resistance, not less than 200; effective length of track 157in ; torque less than 150 g-cm ; mounting, flange and spigot; life expectancy >5000 sweeps at 60 r.p.m.; weight 310 grammes.

A small transformer rectifier unit was one of the interesting items shown by the aircraft division of the Plessey Group of Companies, Ilford, Essex. It is a new design rated at 28V, 15kW, for general aircraft services, with a 40 per cent overload for engine starting. Two six-phase transformers are connected in parallel, with electrical displacement to give a twelve-phase output. Rectification is by silicon cells connected so that each conducts during one-third of a cycle. Cooling is by an integrally mounted fan ; 25 per cent of full load can be taken from the transformer rectifier in the event of fan failure. The overall weight is 50 lb.

Specialised items applicable to the guided missile field, were shown by British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1. They included "Uni-efglas" cables, designed for high temperatures. "Uni-efglas" is rated for continuous operation at temperatures up to 240 deg. Cent. (with a p.t.f.e. and glass insulation developed by B.I.C.C., it is resistant to all aircraft oils and fuels and abrasion and will remain flexible down to —75 deg. Cent.) ; and p.t.f.e. equipment wires (in various code colours) designed for continuous operation up to 250 deg. Cent., with a lapped tape construction to give the wire a tough and highly flexible insulation while providing a thin wall.

A new development is p.t.f.e. multi-core cable with three to twenty-five cores. It is intended as a high temperature version of the miniature multi-way cable to "DEF. 10." These cables are available unscreened, individually or collectively screened, and are suitable for wiring electronic instruments.

Irradiated polythene equipment wires with improved soldering properties, suitable for continuous operation up to 100 deg. Cent., were also shown ; a similar kind of wire can also operate up to 120 deg. Cent. for 1500 hours and for shorter periods (approximately one hour) up to 250 deg. Cent. These wires are available in a limited range of colours.

Another new development was that of sub-miniature coaxial r.f. cables—a complete range of small cables with overall diameters of less than $^1/_{10}$in. A typical example has an inner conductor of 0·0124in silver-plated copper covered steel wire insulated with solid polythene, plain copper wire braided and nylon sheathed to an overall nominal diameter of 0·068in. These cables are of particular interest to designers and users of miniaturised electronic equipment.

Yet another innovation on display was the polypole coupler systems, consisting of multi-core cables terminated with moulded-on couplers, and appropriate panel mounting units to which terminated cables may be connected. They are suitable for application in industrial television systems, remote control, specialised signalling, observation, measuring and guided missile-firing equipment, ground radar, radio relay links and aircraft circuit equipment, and can be made to suit individual requirements.

Prospects of Atomic Energy

In an evening lecture delivered on September 12 at the Palais des Nations, Geneva, Sir John Cockcroft surveyed the work done at the second international conference on the peaceful uses of atomic energy, and essayed a prediction of what the future holds. We reproduce below an abridged version of Sir John's address.

THE three years since the previous conference have been notable for the coming into operation of the world's first large-scale nuclear power stations at Calder Hall, Shippingport and recently Siberia. This has been of great importance since we have thereby begun to acquire experience on the operating characteristics of such stations, and much new information about their technology is being obtained. Our first impressions have been that these nuclear power stations have been docile and well behaved. They can generate electricity for months on end until some minor fault develops. The most usual faults have been the faults of conventional components which require the normal amount of maintenance. There has been a surprisingly small number of defective fuel elements, with failure rates of only three or four per year in 10,000 fuel elements. Reactors using metallic fuel expect to achieve a burn-up of at least 3000MW days per ton, so that 1 ton of uranium will do the work of 10,000 tons of coal. Reactors using uranium oxide fuel expect over three times longer burn-up (10,000MW days per ton), and, indeed, good irradiation stability of small samples has been reported up to 25,000MW days per ton. Our experience of burn-up of *full-scale* fuel elements is now nearly halfway towards the target. Accelerated experience will be gained in future by increasing the enrichment of the fuel.

The nuclear power stations so far built in the world have been either dual-purpose or demonstration stations, and would not be economic as commercial stations. Nevertheless, the experience of their operation has been invaluable in preparing the way for the next generation, which in most cases will be fully commercial stations with credits for plutonium based on its real value for civil purposes. Three main types of second generation full-scale power stations have been described to us ; first, the graphite-moderated gas-cooled reactors ; second, the pressurised and boiling water reactors, and third, the heavy-water-moderated reactors. The capital costs per kilowatt of the first of the commercial nuclear power stations have been very much reduced below those of Calder Hall and Shippingport, but are still over twice those of coal- or oil-fired stations. The papers presented to the conference show, however, that capital costs are likely to continue to fall appreciably during the next decade. The capital costs of U.K. nuclear power stations will fall a further 20 per cent by 1962 as the output goes up from 300MW to 500MW, and a further fall of at least 10 per cent by straightforward engineering developments and increase of output is forecast in a U.K. paper. The boiling water reactor power stations seem to be growing in favour as a result of the good performance of experiments. Because of their low system pressure and small size and comparative simplicity, they may achieve very low capital costs in the next five years.

Fuel costs are the second important component of overall costs, and range from 20 to 40 per cent of the unit cost, depending on whether natural uranium or near-natural uranium or more highly enriched fuel is used. The graphite-moderated and heavy-water-moderated reactors will have the lowest fuel costs. Nuclear fuel costs for gas-cooled graphite-moderated reactors have been given to us as about 2 mils. The Canadians believe that for heavy water reactors they can be brought down to 1 mil. Fuel costs for light-water-moderated reactors have been reported to be about 3 mils. These are to be compared with conventional fuel costs ranging from about 3·3 mils in low fuel cost areas in the U.S. to 8 mils in European countries using imported coal. So nuclear fuel costs should in all cases be lower than conventional fuel costs.

Parity with Conventional Power

The overall economy of nuclear power stations depends greatly on the capital charges, the load factor and fuel costs in a particular country. High load factors are essential to counteract the present high capital costs. A U.K. Electricity Authority lecturer has told us that the first group of nuclear power stations could run continuously if there were no technical reason preventing this. The economic forecasts have, however, adopted the conservative

figure of a 75 per cent load factor. On this assumption the 500MW power station to be completed in 1962 is forecast to achieve parity with coal-fired stations in areas in Britain away from coalfields. On the basis of our experience so far, these power stations seem likely to achieve an appreciably higher load factor, whilst fuel costs are likely to fall as burn-up increases with the development of our technology and as uranium prices fall, so forecasts may be conservative.

By the late 1960s as the installed capacity of nuclear power stations grows, the available load factor will fall. By that time, however, this is likely to be more than compensated by further reduction of capital costs of the order of 20 to 30 per cent, resulting from higher temperatures of operation and higher ratings associated with a switch to ceramic fuels. Nuclear power costs in Britain are therefore forecast to fall well below conventional costs by the late 1960s.

The date of achieving parity will be later in countries such as the U.S. where hydro-electric stations and stations using low-cost coal or natural gas can generate power at 4 mils. We have been told that stations started in the U.S. in the late 1960s should achieve parity.

In Italy, the World Bank study for the S.E.N.N. nuclear power station has shown that with the assumed 14 per cent capital charges, nuclear power would be about 10 per cent more costly than power from oil, and that there is little economic difference between the various types. India has reported that the first 150MW power station to be built in India could achieve parity. We see, therefore, that the date for achieving parity ranges from 1963 to 1973, depending on the circumstances of individual countries. This date will determine the rate at which large-scale installations of nuclear power stations will develop. O.E.E.C. predict that Western Europe will have an installed nuclear capacity of 10,000MW by 1965. The U.S. has predicted 1300MW by 1963, and the U.S.S.R. 2000MW by early 1960s. All of this might add up to an installation of about 15,000MW between 1965 and 1970.

There is general agreement that by 1975 most new power stations will be nuclear.

Dr. Bhabha, in his evening discourse, has dealt with the need for atomic energy in underdeveloped countries, taking as his definition countries where *per capita* income is low. Since India comes very low in the table of *per capita* income, it comes in this category. Indian power requirements are doubling every six or seven years, and Dr. Bhabha considers that nuclear power stations would be competitive now and may have an installed capacity of 500MW by 1965. Japan seems to be in a similar situation and predicts 750MW by 1965. The growth of nuclear power in other underdeveloped countries will depend on their indigenous fuel supplies and on the available loads, and on their state of technological development. It will be hard for nuclear power to compete with diesel power where power requirements are less than 30MW, and load factors are low. It should be remembered that technicians are scarcer than graduates in many countries, and they are crucial to this development. I agree with our President that nuclear power will not perform miracles in underdeveloped countries.

By the late 1960s new, third generation, types of stations may be coming into service. We have had reports of operational experience with their precursors, the reactor experiments. The organic-liquid-moderated reactor experiment has shown that it is likely to be a simple reactor to operate because of its low system pressure and its non-corrosive, non-radioactive coolant. The previously unknown cost of replacement of the moderator required by radiation breakdown seems to be about 1 mil per kilowatt hour. The Oak Ridge experience on the aqueous homogeneous reactor shows good progress in overcoming the difficult compatibility problems, but the stability of the fluid fuel is still a crucial point. The sodium graphite reactor experiment will provide important information on sodium technology and on metallic fuel elements operating at high temperatures. The high-temperature gas-cooled reactor projects using all-ceramic fuels may well be important for propulsion as well as for land use by the end of the 1960s. A high-temperature gas-cooled reactor experiment seems likely to be built in Britain as a collaborative European joint project.

Fuel Cycles

It seems clear that with the general trend to the use of uranium oxide fuels, most reactors built after 1965 with the possible exception of the heavy water reactors, will require some enrichment. The graphite-moderated reactors will require only modest enrichment of the order of 1 per cent U^{235}. The light water moderated reactors will require enrichment ranging up to 3 per cent U^{235}.

The enrichment can be provided either by diffusion plants or by using plutonium from earlier reactors. Thereafter they could operate on a natural or slightly enriched uranium feed by recycling plutonium, using this in the form of oxide mixed with uranium oxide. We have heard of promising technological work on recycling and of the limitations imposed by the accumulation of higher isotopes such as Pu^{242}. One of our speakers has predicted that by the time nuclear energy is producing 20 per cent of world power, we should need to invest about 5 per cent of the capital for nuclear power programmes in diffusion plants to provide the initial charges of uranium of low enrichment.

An alternative fuel cycle is to feed the plutonium to reactors of the fast breeder type which will have a positive gain factor for plutonium. The advantage of this would be in the long term a much better utilisation of world uranium supplies. The super-abundance of uranium which is forecast for the next two decades has shown that this is not an urgent problem. We can therefore take time to develop the difficult technology of fast reactors in a thorough manner. We have heard reports in this conference on the results obtained with experimental fast reactors ; from their operation we have gained a great deal of knowledge about the physics, kinetics and stability of these reactors, which has been important in the design of the higher power experiments which will come into commission during the next two years. Already, however, prototype fast reactor power stations of 50MW to 200MW electrical output are being constructed and designed. The rate of installation of fast reactors will depend first on our experience with the reactor experiments, and second on the rate at which plutonium becomes available from thermal reactors. Fast reactors are unlikely to contribute much to world power before the 1970's.

Thorium possesses considerable advantages as a fuel for thermal reactors, but a large investment of U^{235} or plutonium is required to start the thorium cycle. We have had a description of the Indian Point 275MW(E) nuclear power station, the first full-scale reactor which will use the thorium cycle. Thorium may well be coming into use by the late 1960s, especially since large supplies will be available as a by-product of uranium mining. World thorium reserves seem likely to be at least 500,000 tons. At the 30 per cent burn-up which might be achieved by breeding, 10,000,000 tons of uranium is equivalent to 10^{13} tons of coal, which is three times the world's estimated coal reserves. We are likely to have developed fusion power long before we run out of uranium.

Nuclear Propulsion

The feasibility of the nuclear propulsion of shipping has been abundantly demonstrated by the voyages of the U.S. submarine " Nautilus," culminating in the remarkable voyage underneath the polar ice cap. The pressurised water reactor used to develop steam for its propulsion has proved to be highly reliable. We have heard of the first approaches to commercial nuclear propulsion. The U.S. " Savannah," a combined passenger-cargo ship coming into commission in 1960, will use a pressurised water reactor developing 22,000 s.h.p. The unit seems likely to achieve fuel costs, based on U.S. prices, about equal to those for oil fuel. Present capital costs are, however, three to four times higher than conventional capital costs, and a drastic reduction of these costs is necessary before parity with conventional propulsion is achieved. The U.S.S.R. expect to build a nuclear tanker using a boiling water reactor for propulsion by 1962. Since this type appears to have lower capital costs than the PWR this should help to bridge the gap, though operating costs will still be well above conventional costs. It seems likely that we will have to wait five years or more before we will know whether truly commercial nuclear propulsion is a feasibility. However, there is one immediate application which would be impossible without nuclear power. The opening up of the 6000-mile seaway north of Russia has had to wait for the practically unlimited endurance of the nuclear propulsion unit, and we have heard details of the icebreaker " Lenin," which is due to be commissioned in 1959. Three pressurised water reactors will provide 44,000 s.h.p. for propulsion.

In contrast with the hopeful outlook for marine applications, commercial nuclear aircraft propulsion seems much further away.

Fusion Reactors

In his presidential address to the last Conference, Dr. Bhabha predicted that a method would be found for liberating nuclear fusion energy in a controlled manner within the next two decades. The papers presented to this conference on fusion research have shown that remarkable progress is being made in this field. Most workers have in view the long-term objective of attaining " temperatures " of 50 to 100 million deg. in a mixture of deuterium and tritium gas. This should enable the " break-even point " to be reached at which the energy release from fusion reactions in a mixture of deuterium and tritium gas would equal the energy input. The long-term goal is to go well beyond the 100 million deg., to use the deuteron-deuteron reaction and eliminate the dependence on lithium as a source material for tritium.

Although we have been using the word " temperature " as a measure of our progress, we should remember that it is not strictly applicable to these very complex hot plasmas. We have also to remember that the electron temperatures are often very different from the deuteron temperatures, and it is the latter which are important for our objective.

We have had reports from several laboratories that "temperatures" up to several million degrees have already been achieved in deuterium gas, with prospects of going considerably beyond this in the future. It is necessary, of course, to be able to hold these high temperatures for a sufficiently long time for an appreciable proportion of the deuterium to be burnt. Thus at a temperature of 50,000,000 deg. in a deuterium-tritium mixture and with gas densities of about one-thousandth of an atmosphere, only 1 per cent of the deuterium would be fused in a tenth of a second. The containment of this high-temperature gas depends in all cases on the use of magnetic fields, the so-called "magnetic bottle." The containment also depends on being able to maintain this hot, tenuous plasma, generating and radiating energy at a great rate, in a stable configuration not subject to violent oscillations or eruptive processes leading to loss of energy.

Two main lines of attack on the fusion reactor have been described to us. The first is the pinched high current discharge method, used in the "Zeta" and other tori, the "Stellarator" and the straight discharge tubes. The stability of the plasma depends critically on the relation between the magnetic fields produced by the circulating current and the additional magnetic fields applied to produce containment and stability. In "Zeta," containment is not well understood and we do not yet know how far we will be able to maintain containment as energy input is increased. We have heard that other torus devices can lose large amounts of energy by runaway electrons escaping to the walls of the tube, and that the production of a quiescent plasma is the crucial problem.

In the torus devices the plasma is heated by resistive, shock wave, or radio-frequency methods. "Temperatures" have so far been measured by Doppler broadening of highly ionised impurity atoms, or by even more indirect methods. It seems that deuteron temperatures of several millions of degrees may have been reached but that electron temperatures are much lower.

The second class of fusion device known as the "mirror machine" also contains the plasma in a "magnetic bottle" but the plasma is heated in a different way. In the "Pyrotron," the first of the mirror machines, the plasma has been heated by using pulsating magnetic fields like pistons to compress the plasma, and electron temperatures of about 10,000,000 deg. have been reported. In the Oak Ridge DCX machine a plasma is formed by passing intense beams of high-velocity molecular ions into a chamber where the molecules pass through a powerful carbon arc and are split up into neutral and charged hydrogen atoms. The neutral atoms leave the plasma and the charged atoms are trapped in the magnetic bottle and form a hot plasma. The progress of this method will depend critically on producing several amperes of molecular ions and on keeping the loss of energy from the plasma low; the method will be watched with great interest. The U.S.S.R. "Ogra" machine which has just been completed will work on a similar principle, but the molecular ions are to be split up by impact with the atoms already there in the course of a long spiral path to and fro between the magnetic mirrors. These mirror machines also will depend for their success on being able to maintain a quiescent plasma.

Fusion reactors will aim ultimately at developing several hundred megawatts per cubic metre of plasma, so that they may not be very different in size from fission reactors. It is too early to judge the relative prospects of the different approaches to fusion power demonstrated so well in the exhibition—so much depends on experiments still to be carried out. Although neutrons emitted after the fusion of deuterium nuclei have been observed from many of the devices, the deuterons responsible have so far been mainly speeded up by direct processes. No laboratory has so far claimed what have been called "true thermo-nuclear reactions" though we are probably not far away from this. However, I agree with Academician Artsimovich that this is not the important question. The origin of the neutrons will become clear enough if we can increase the temperatures in our plasmas. The important question is whether we can maintain stability in our plasmas as we feed in more and more energy, and whether we can, in due course, reach the break-even point where the energy generated by fusion equals the energy input. Dr. Thonemann thinks this may well take ten years, and that even if we are successful it is likely to take at least another ten years before we know whether an economic fusion power station is practicable. I agree with this. Dr. Teller's timescale is even longer.

Uses of Isotopes

The multitudinous industrial uses of radio-isotopes continue to increase rapidly. Dr. Libby has estimated that their use in process control, in the oil industry and other production fields, is already saving United States industry 400 million dollars a year and that the savings will soon reach the multi-billion dollar level. Academician Topchiev has reported that the present annual savings to Soviet industry by their use amount to over 1000 million roubles. Several million metres of oil well bores have been logged by neutron sources.

Sources of radiocobalt and of radio-caesium are shortly becoming available in strengths of the order of 100,000 curies, for industrial applications. These powerful sources will be used for sterilisation of hospital dressings, pharmaceutical products and other materials where chemical sterilisation is less attractive. They can be used to produce grafted polymers in which the properties of the original polymer are beneficially changed. Thus, Dr. Libby told us that a styrene-polyethylene film had been used to make an ion exchange membrane which had much improved properties for purifying brackish water. Dr. Topchiev has reported the production of block polymers of polyethylene and polystyrene which have high strength and stability up to 250 deg. Cent. Many more chemical applications are promising, and we are likely to make full use of the tens of millions of curies of radio caesium and radio cobalt which could become available as by-products of the power programme.

The movement of silt in river estuaries and harbours is now being studied with the help of radioactive tracers in many parts of the world, following pioneering studies in the Thames estuary. Gold and tritium labelled water is being used to determine the flow of water in rivers, sewers and underground strata. This may have important applications to the survey of water resources in underdeveloped areas, and for the control of irrigation in arid areas.

Fundamental Research

We have been both entertained and instructed by our sessions on fundamental research. New giant accelerators have been described to us, and we have heard that the cosmic ray workers flying large stacks of photographic emulsions in "Comet" proving trials have been able to obtain an enormous amount of new data on the collision of protons 10,000 times more energetic than any which can be produced by the largest planned accelerators. We have also heard of the new discovery by the orbiting satellites of intense belts of 40,000,000V protons, 1000km or so above the earth in particular latitudes. The great question of why pions and nucleons exist with their particular masses and particular interactions remains totally unanswered, in spite of the wealth of new knowledge produced by the accelerators. Strange particles accumulate, and now total thirty-one. The theoreticians have a new occupation of inventing new rules and waiting to see whether the latest strange particle obeys them. Dr. Feynman has predicted that twenty years hence our successors may be convening a Conference on the Peaceful Uses of Strange Particles.

In the field of nuclear data we have heard that the present situation leaves no room for complacency, since present reactor technology requires much more precise information which we shall have to work hard to obtain. To help in this, important new tools providing enormously powerful pulses of neutrons are becoming available.

We have had a rich feast, perhaps too rich, at this conference, not only from the lectures, but from the exhibitions, which have enabled us to see in a few days, in an exciting visual way, work proceeding throughout the world. We have also held innumerable discussions in small groups to amplify the knowledge gained in our formal sessions. This is the classical method of co-operation in the scientific world. We will go away with a great deal to think about and this conference, like the 1955 conference, is likely to have a profound effect on the development of atomic energy in the future.

Technical Report

Some Results of an Investigation into the Use of Air Injection in a Model of the Diffuser for the A.R.A. Supersonic Tunnel. By E. C. Carter and K. F. Tucker. A.R.C. Current Paper No. 386. H.M. Stationery Office, Price 5s. 6d.—The use of air injection in the diffuser of the Aircraft Research Association supersonic tunnel has been investigated to determine the decrease in running and starting pressure ratios obtained at a given Mach number. The tests were made in a 4in by 4in working section tunnel operating with atmospheric downstream pressure; the majority being conducted at $M=3{\cdot}15$, giving a Reynolds number of approximately 2,400,000, based on tunnel height, compared with 5,400,000 for the full-scale tunnel. Air injection at tunnel stagnation pressure was made at two slots in opposite walls of the diffuser at a distance four tunnel heights downstream of the working section. This initial portion of the diffuser could be contracted to determine the most efficient entry conditions to the injection section. The angle of injection was 15 deg. to the tunnel axis at a constant Mach number of $1{\cdot}63$. Control of the direction of the injected stream and size of second throat was provided by adjustable flaps downstream of injection.

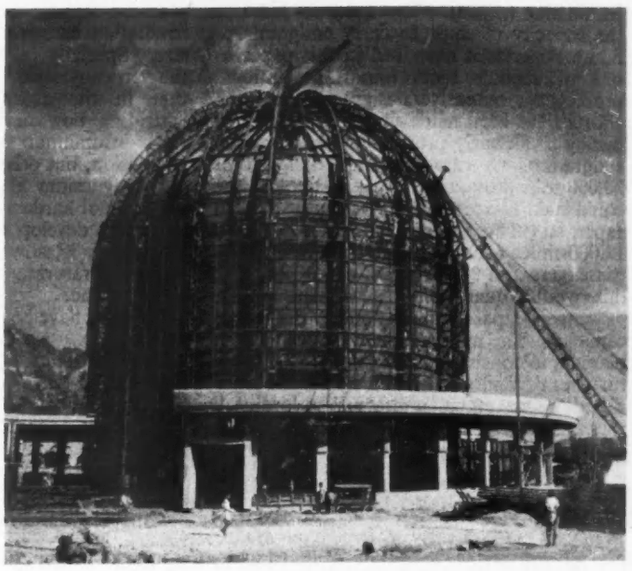
It is shown that the use of 120 per cent by-pass injection at $M=3{\cdot}15$ permits the starting pressure ratio to be reduced to $3{\cdot}2$ from values in excess of $4{\cdot}0$ and the running pressure ratio to be reduced to under $3{\cdot}0$; both figures being obtained with a representative model and support in the working section. It is also shown that further decrease in pressure ratio can be obtained with the use of larger injection quantities.

In addition to the main tests, the effects of model incidence and a hole in the floor of the working section were investigated. Also three different subsonic diffuser shapes were tested in the presence of the disturbed flow from the supersonic diffuser. The results of this latter test indicated that it is essential to maintain an expansion rate equivalent to a 6 deg. cone or less, even if it means decreasing the expansion area ratio of the subsonic diffuser.

Conference on "Atoms for Peace"

No. II—(*Concluded from page 411, September 12*)

In No. I we presented abstracts from some of the papers at the second international conference on the peaceful uses of atomic energy. These related to controlled thermonuclear fusion, gas-cooled reactors and pressurised water reactors. A further selection of abstracts is given below, and a brief description of the scientific exhibition that was held concurrently with the conference. One of the exhibits, a photograph of which is reproduced here, shows progress on the C.I.R., or "Canada-India Reactor."



THE abstracts presented in No. I related to the control of thermonuclear fusion and to two well-known types of fission reactor, the gas and pressurised water varieties. Naturally, this immense international conference considered many other types of fission reactor besides these, but it is impossible in the space available to us to give even a representative sample of all the subjects treated. The further selection of papers, of which abstracts appear below, is therefore necessarily arbitrary.

Marine Propulsion

Safeguards Considerations in the American Nuclear Merchant Ship Program. By Richard P. Godwin and Douglas L. Worf (U.S.A.).—The main design features of the first merchant ship being built under the American nuclear programme, the "Savannah," are briefly described. Particular attention is paid in the paper to containment, shielding, waste disposal, instruments and control. The "health physics programme" for the ship is detailed, including the radiation limits for passengers and crew, the radiation monitors, and the analytic services. Manning and training requirements are outlined. "Credible emergencies" are described and evaluated, and the safety of the ship's reactor compared with that of land plants.

The Nuclear Propelled Icebreaker. By N. S. Khlopkin (U.S.S.R.).—As is now well known, a nuclearly propelled icebreaker was launched some time ago in the Soviet Union. The present paper describes the vessel as having a displacement of 16,000 tons and main turbines of 44,000 h.p. Navigation is possible for more than a year without refuelling. The icebreaker can move through fields more than 2 yards thick at 2 knots, and has a speed of 18 knots in free water. Each reactor has an independent primary circuit containing pressurised water. The secondary circuit provides superheated steam to drive the main and auxiliary turbogenerators. There are four main turbines, each of 11,000 h.p. Direct current is generated to drive motors coupled to three shafts. The auxiliary generators produce alternating current of "commercial" frequency. The biological shield is in alternate layers of iron and water, with dense concrete in regions where the geometry makes the placing of water tanks difficult. The primary circuit zone is kept at sub-atmospheric pressure to prevent the spreading of radioactive matter; the air is discharged through a hollow mainmast. When necessary, e.g. for maintenance, active water may be discharged from the circuit into protected tanks. It is dumped into the sea only after cooling and filtering in ion exchanging filters which reduce activity to a permitted level.

The nuclearly propelled Russian ice-breaker "Lenin," which is of 16,000 tons displacement

On the Possible Use of Water and Gas Reactors on Board Ship. By R. Gibrat, L. Bureau du Colombier and J. Ricard (France).—The French Atomic Energy Commission has organised a competition for the design of a nuclearly propelled oil tanker of 40,000 tons displacement and 20,000 h.p. maximum. The paper reports a study of the characteristics and difficulties of three types of reactor considered for the task. Gas-cooled reactors with gas turbines are a long-term solution, pending the achievement of high enough temperatures, but it is thought that, before then, gas reactors with steam plant "may be interesting." The drawbacks of weight, bulk and difficult fuel handling are said to be far from making this solution unfeasible, for conventional marine machinery (450 deg. Cent., 45 kg per square centimetre) may be used. The reactor, heat exchangers and blowers are contained in a vessel 12m in diameter and 18m in length. The outlet temperature is 500 deg. Cent. Such a reactor is described as intermediate between a large land station and a closed-cycle gas-turbine reactor. The propelling machinery required for a pressurised water reactor is said to require a hardly larger or better qualified crew than that of a conventional tanker. Study has been devoted to safety, materials, and the kind of land installation needed for upkeep of nuclear equipment and loading of fuel. The report examines the possible effects of a ship's motion on a boiling water reactor. Particular attention is paid to the influence on circulation rate and the requirements for stability. The steam separating equipment and stabiliser are described, as is the standby refrigerating system in case of scram and closing of the secondary circuit valves.

Nuclear Powered Emigrant Ship. By Seiichi Takeuchi, Takashi Okamora and Sotoo

Murakami (Japan).—The need to increase the capacity of ships to carry emigrants to South America is described in this paper as one of Japan's most important national problems. Extensive design and research efforts have been made with a view to producing a nuclearly propelled vessel for such emigration. A ship has been designed of 20,000 tons gross, cruising at 23 knots. She could make five round voyages a year between Japan and the east coast of South America, 12,000 miles each way, carrying about 2200 passengers and 9000 tons of cargo per trip : this would quadruple the present annual passenger capacity and double the cargo capacity. The main propelling machinery is planned to consist of two sets of 22,000 s.h.p. turbines driven by saturated steam, the latter raised by means of a pressurised ordinary water reactor. The economics is examined in the paper.

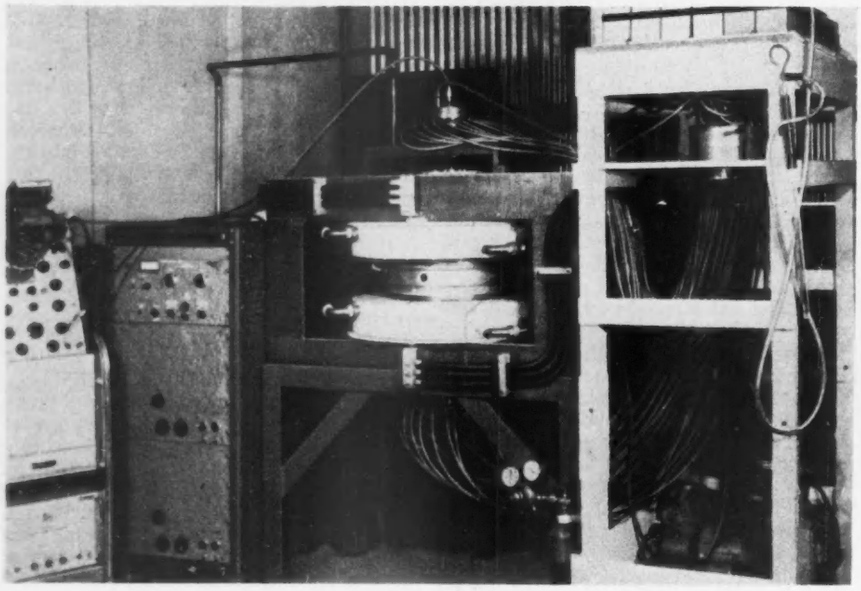
Materials

Mechanical Properties, Embrittlement and Metallurgical Stability of Irradiated Metals and Alloys. By M. J. Makin, A. T. Churchman, D. R. Harries and R. E. Smallman (U.K.).—The change in the tensile properties of a number of metals used in reactors is described in detail. The metals tested include titanium, zirconium, "Zircalloy 2," molybdenum, tungsten, mild steel, nickel, copper and certain magnesium alloys. Generally the results show an increase in yield and ultimate strengths and a decrease in elongation to fracture. A model for the mechanism of irradiation hardening is suggested on the basis of research done. The increase in the transition temperature of welded steel plates has been measured after irradiation at various temperatures, and for the larger grain sizes it has been found that the increase is proportional to the cube root of the neutron dose. The increase is accompanied by a decrease in the energy absorbed during fracture.

Fuel Element Behaviour Under Irradiation. By V. W. Eldred, G. B. Greenough and P. Leech (U.K.).—Changes in fuel elements in the Windscale and Calder Hall reactors are described. Surface wrinkling of natural uranium fuel is shown to depend on the irradiation temperature as well as the grain size. Specially interesting is the bowing of the vertically stacked elements. It is shown that in the absence of constraints, the cartridges bow at the originally predicted rate. Aluminium cans harden a little with irradiation, but otherwise show little change. The magnesium alloy cans used in Calder Hall do not harden under similar conditions, but may develop small voids at the grain boundaries if slowly strained, especially at low temperatures. A summary is given of some of the important causes of cartridge failure that have been examined.

Production and Recovery of Radiation Effects in Metals. By D. K. Holmes, J. W. Corbett, R. M. Walker, J. S. Koehler and Frederick Seitz (U.S.A.).—The noble metals, particularly copper, have recently received special attention. Irradiation at temperatures near 10 deg. K. with fast reactor neutrons electrons and gamma-rays of about 1·5 MeV, and deuterons of 10 MeV, has shown : (i) the change in electric resistivity with flux ; (ii) the annealing that occurs when specimens are warmed from near 10 deg. K. to room temperature ; (iii) the release of stored energy during annealing ; (iv) the change of lattice parameter and linear dimensions during bombardment and annealing ; (v) the influence of alloying additions and cold work on annealing behaviour ; (vi) the effect of consecutive irradiation at liquid nitrogen and helium temperatures on the change of resistivity and annealing ; and (vii) the changes in the elastic moduli. The existing information does not provide a unique interpretation of the effects observed so far.

Effects of Irradiation on the Structural Materials in Nuclear Power Reactors. By J. C. Wilson (U.S.A.).—The mechanical properties of more than fifty wrought metals and welds have been found after doses of 10^{18} to 10^{20} fast neutrons per square centimetre at various irradiation temperatures. The influence of composition, heat treatment and microstructure on sensitivity to radiation has been studied for a number of materials. Structural metals are among the least liable to adverse effects from irradiation, but there are places where the effects of radiation may strongly influence the design, construction and operation of reactor components. Carbon and low alloy steels are the only economic materials for pressure vessels in many cases, but even without radiation it is hard to get enough notch ductility to avoid catastrophic brittle fracture. Irradiation above 10^{18} fast neutrons per square centimetre can sharply lower notch ductility in steels. Tests on over thirty-five ferrous materials have shown the ill-effects of irradiation to depend on composition, microstructure and heat treatment. Steels much more resistant than others exist and can be selected for pressure vessels. There is evidence that weld metal may be more sensitive than the best wrought materials. Anomalies in behaviour of irradiated steels suggest that responses to stress, strain and temperature in service may be quite different from those of unirradiated steels, and new ways of interpreting mechanical tests may be needed. In irradiated face-centred cubic metals the tensile stress curves show a yield point and the yield stress is strain-dependent. Also the uniform elongation is markedly reduced in some materials. The influence of the unique properties of irradiated metals on design is discussed.



The homopolar device ; a rotating plasma is produced by passing a high current radially through a low density gas in the presence of an axial magnetic field. Both viscous and resistive effects cause heating, whereas magnetic mirror and centrifugal effects afford plasma containment

Other Uses of Atomic Energy

Application of Radio-Tracers to the Measurement of Engine Wear in Moving Vehicles. By J. H. Deterding and J. R. B. Calow (U.K.).—The use of radioactive parts in engines makes it possible to measure wear under various conditions. The paper describes the use of the method to study piston-ring wear in a car engine in actual running conditions, the measurements being recorded in the moving vehicle.

Non-Military Uses of Nuclear and Thermonuclear Explosives. By Harold Brown (U.S.A.).—The enormous energy of thermonuclear explosions may be used for excavation and the generation of power. The cost of thermonuclear explosive may well be 1/50,000 of that of conventional explosive for multi-megaton yields and 1/2500 or less for energies in the 100 kiloton range. Fuel costs for thermonuclear explosions to provide power are also smaller than those for conventional (or fissile) fuels. The main problem is the containment of the energy in a usable form. The best prospect is for underground containment, either in a large hole or in pulverised rock. In both cases the poor thermal conductivity of the rock keeps the heat in. One megaton of T.N.T. equivalent, if 25 per cent of the energy is recoverable, provides 30MW years of electrical energy.

Underground Nuclear Explosion. By Gerald W. Johnson (U.S.A.).—An underground nuclear explosion was initiated on September 19, 1957, at the Nevada proving ground of the U.S.A.E.C. The detonation took place at the end of a 1700ft tunnel in the side of a mountain, in rock (called "tuff"). Calculations indicate, and experiments confirm, that more than 99 per cent of the energy, 1·8 kilotons, was contained within a radius of 30ft to 50ft, going into heating and compressing the rock. Almost no radioactivity was detected beyond 200ft and none at all was vented to atmosphere. Most observers 2½ miles away felt no earth shock.

Use of Nuclear Energy for Purposes Other Than Generation of Electricity. By W. H. Zinn (U.S.A.).—Reactor-produced steam can be used wherever the cost is competitive with that of conventional methods. Present and future costs for space heating, evaporation and purification of water, heating and drying in, e.g., the paper industry, and direct use of steam in chemical processes (such as

gasification of coal) are analysed. Reactors for producing high-temperature gases are discussed and the principal difficulties considered. Marine propulsion is discussed in the light of the known costs, and the use of a high-temperature gas turbine for ship propulsion is examined.

Application of Radioactive Isotopes for the Investigation of Metallurgical Processes. By N. G. Bogdanova, P. L. Gruzin, G. I. Ermolayev and I. D. Nikulinski (U.S.S.R.).—At the Kuznetsk works radioactive isotopes are used to investigate steel-making and other processes. The stirring of metal in ladles and open-hearth furnaces was studied in this way, and the results helped to determine the time needed for uniform distribution. The effect of acting on the inferences from this work has been an increase in steel output by as much as 75,000 tons a year and a money saving of 1,000,000 roubles a year, at the Kuznetsk works alone.

Adam: A 75MW Nuclear Energy Plant for House Heating Purposes. By I. Wivstad and C. Mileikowski (Sweden).—For some years the town of Västerås has been supplied by a district heating plant. Increased demand is to be met by an underground reactor putting out 75MW: the subterranean site has been chosen for safety. Water leaves the reactor at 140 deg. Cent. The fuel elements are in clusters. The elements consist of sintered oxide pellets in aluminium cans. Heavy water moderates, reflects and cools the core, and the filling gas is helium.

Use of Radioactive Isotopes for Production Checks on the Continuous Casting Process. By J. Fodor and Ch. Varga (Hungary).—In the continuous casting of different steels, drawing rates and cooling must be chosen to suit each other. The values can be found when the depth and profile of the liquid zone in the die are known. Radioactive isotopes have been used to determine these. A tungsten ball with Co^{60} tracer was thrown into the liquid and sank to the deepest point, which could therefore be located in the billet. The profile was found using P^{32} tracer. This was put in lead balls which were threaded on to a 5mm steel rod 2m long. The rod was pushed into the liquid zone. The lead melted and the phosphorus polluted the liquid but not the solid. After cooling the billet was sectioned and autoradiographed.

THE SCIENTIFIC EXHIBITION

A very brief reference to the scientific exhibition appeared in our issue for August 29, page 324. A rather more detailed account of the main stands is given below. The dominant theme of the exhibition, as of the conference, was the work now proceeding, mostly in the U.K., U.S.A. and U.S.S.R., on the control of thermonuclear fusion reactions.

United Kingdom

The power and research programme was portrayed in its evolution from the beginning with Calder Hall. Models were shown of the stations now being built at Berkeley, Bradwell, Hunterston and Hinkley Point. A schematic model represented a combined nuclear and hydro-electric station using pumped storage. There was a model of the 10MW high-temperature reactor experiment to be constructed at Winfrith Heath with the aim of attaining a highly efficient steam or gas cycle. Actual parts of the zero-energy reactors "Zephyr" and "Zeus," used for obtaining physical data on fast breeder reactors, were shown. A working model was exhibited of a Harwell apparatus made for the measurement of heat transfer coefficients and pressure drops with steam-water mixtures in various sizes of concentric annuli at about atmospheric pressure.

The principal interest of the stand lay in its treatment of research on the control of thermonuclear reactions. A general introduction explained the significance of the investigation and outlined the work done so far at A.E.R.E., Harwell; A.E.I., Aldermaston; and A.W.R.E., Aldermaston. The criteria for controlled thermonuclear reactions were given and the problem of containment discussed on display panels. Early studies on a metal torus at Harwell were described, and "Mark I" was exhibited. Experiments to overcome instability led to the "Mark III" torus which was the prototype of "Zeta." A one-third scale model of the latter was shown on the stand. A diagram of the X-ray detecting equipment was displayed with a graph of emission against time during discharge. More diagrams and photographs indicated the method of using (*a*) the refraction and reflection of microwaves by the plasma to investigate its density, and (*b*) the microwave radiation from the plasma to infer the electronic temperature within it. The variation of the magnetic field with time was also portrayed. The neutrons from "Zeta" had been studied, using a diffusion cloud chamber at 110 lb per square inch and −30 deg. Cent., this in order to measure the mean velocity of the centre of mass of the D–D reaction. Photographs of the cloud chamber were shown with diagrams of the results. A model of another celebrated torus, "Sceptre III," was also displayed. One of the more popular exhibits was a working assembly known as "Minni." This was a one-third-scale replica of the linear discharging device called "Maggi" at A.W.R.E.* "Minni" comprised 200 condensers, each of 0·8 μF, working at 5kV and storing 2000 joules. There were 200 spark gap switches, one per condenser, triggered to break down within 0·006 μsecond. The multiple switching system reduced the parasitic inductance and so increased the rate of energy release. The apparatus had been built in seven weeks from conception. Observations with high-speed cameras (image converters and Kerr cell shutters) showed a good pinch, and 10^4 to 10^5 neutrons were emitted per pulse. Neutron emissions from a bank of such low voltage and energy had not previously been reported, and investigation proceeded during the exhibition.

Surveying and assaying instruments were shown on the stand. Instruments for use in low-flying aircraft, in cars, and on foot were included.

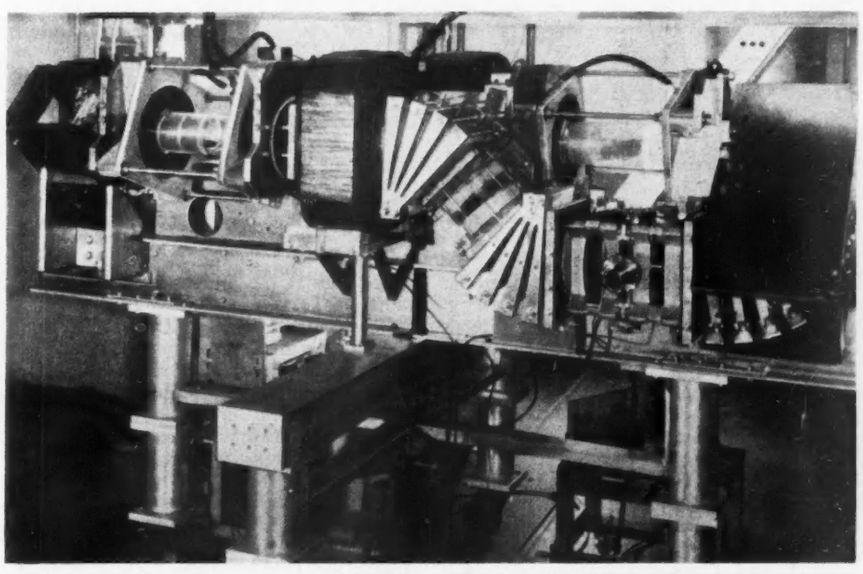
The metallurgical section included a demonstration of a new technique for firing long metal and ceramic compacts, and exhibits illustrating work on liquid metal technology.

A reactor transfer function analyser was shown. The sinusoidal perturbation of reactivity is obtained by rotating a half cylinder of neutron-absorbent material in the reactor.

United States

The most magnificently appointed stand at the scientific exhibition was that of the United States. There were four sections dealing respectively with fundamental work, biological and medical matters, fission reactors, and research on nuclear fusion.

In the section on what were called "basic sciences" there were displays on recent developments in nuclear physics and chemistry. A model, accompanied by graphs, showed how neutron scattering experiments have led to inference of the size, shape and structure of nuclei. A full-scale animated model was exhibited of the equipment used to measure some of the properties of the neutrino. The recent discovery of the anti-proton and anti-neutron† was marked by a display of the kind of photographs of mutual annihilations that established the identity of these particles. An operating bubble chamber was on show, with tracks made visible to spectators by closed-circuit television. Normally such tracks are photographed. A device was also demonstrated that projected



The B-2 research "stellarator," part of the U.S. fusion exhibit at the Geneva Conference. This 'stellarator," of the "figure-eight" type, was built in 1955 at Princeton University, U.S.A., for basic experiments on the confinement and heating of ionised gas. In normal operation, it has a magnetic field of 27,000 gauss

* See illustration in No. I, page 410.

† An anti-proton is an artificially produced particle with the same mass as a proton but with a negative charge; it is very short-lived. An anti-neutron is an artificially produced particle with the same mass as a neutron but with magnetic moment of opposite sign.

the photograph on to a ground glass screen and automatically followed the tracks ; co-ordinates were recorded on punched cards during the motion. The cards could be fed to an IBM 650 computer nearby, and the particles' identity, energy, angles of path and momentum could be found.

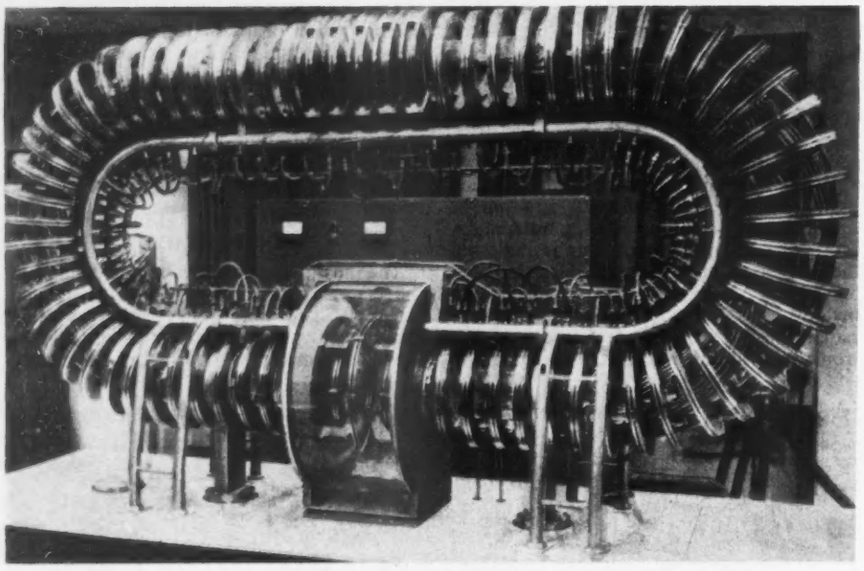
A full-scale model of the Shippingport pressurised water reactor was supplemented by a detailed model of the whole plant. A large operating section of the control room and console of the experimental boiling water reactor at the Argonne National Laboratory was represented. A one-seventh scale model of this reactor responded to operation of the console. Plans for a sodium-graphite power reactor at Hallam, Nebraska, were presented, and a model of the second homogeneous reactor experiment at Oak Ridge was shown. A model of the nuclearly propelled ship " Savannah " illustrated the exhibit on the maritime reactor programme. Panels were devoted to the U.S.A.E.C.'s programmes for molten salt and liquid metal fuelled reactors, plutonium recycling, and gas-cooled reactors burning either natural or slightly enriched uranium. A research and training reactor, the " Argonaut," was assembled and demonstrated during the exhibition. ‡ An integrated display illustrated the nuclear fuel " cycle," from the extraction and refinement of the uranium ores to form U_3O_8, through the conversions to the orange oxide UO_2 and the green salt UF_4 respectively, to the normal oxide or metal ; or from the green salt to the hexafluoride, which is enriched in a gaseous diffusion plant.

Each of the four American laboratories working on thermonuclear fusion had a part in the section devoted to this subject. The generic name " stellarator " has been given by the Americans to endless discharge tubes which rely on a twisted magnetic field to contain the ionised gas in equilibrium. The field is generated by external windings, and the twist is introduced either by using a figure-eight shape or by using additional windings on a racetrack-shaped tube. Each of these methods was illustrated by a model. The actual B–2 research " Stellarator " was shown in operation. Of the figure-eight variety, this device is normally worked with a confining field of 27,000 gauss. Equipment for measuring the confining field, plasma current and voltage, light intensity, electron density and X-ray generation was displayed. Models of the new " Stellarator " research laboratory now being built at Princeton University were also exhibited.

Work on linear and toroidal pinches is carried out at the University of California Radiation Laboratory, and was represented on the stand. The magnetic mirror machine is also being investigated by U.C.R.L. The display relating to this device demonstrated the path that a beam of energetic ions could have in a magnetic mirror field. In the region between the mirrors (zones of intensified magnetic field) ions follow helical trajectories around lines of force. As they penetrate the strong field they meet resistance and the trajectory becomes practically circular. The third principle under examination in California is that of the " astron " machine. Very fast, so-called *relativistic*,§ electrons are injected into an evacuated vessel and an externally imposed magnetic field forces them into circular orbits. The electrons create a magnetic field which, in combination with the external field, confines the plasma—provided that the number of rotating electrons exceeds a critical value. Properly injected neutral atoms are ionised by the relativistic electrons, providing a cold plasma. The relativistic electrons lose energy to the plasma by Coulomb collision, heating it. The first experimental machine is now being made, and was represented to one-tenth scale at the exhibition.

The display by the Oak Ridge National Laboratory was devoted to the " DCX " or d.c. experiment. Through a side window in a metal enclosure 3m by 1·5m by 1·5m visitors could see a glowing ring 20cm in diameter (see title illustration for No. I, THE ENGINEER, September 12, page 408). The light was emitted by minute carbon dust that became incandescent on collision with fast deuterons : the carbon dust was put in deliberately for better visualisation. In the " DCX " particles are shot into a highly evacuated tank with initial energies of 600,000 eV. Being so energetic, these particles would normally be very difficult to trap by means of, say, magnetic mirrors. The deuterium molecular ions in the Oak Ridge device, however, are broken up by a d.c. carbon arc into atomic ions, one of neutral deuterium which escapes, and the other a positively charged deuterium nucleus which stays trapped in the magnetic field. An unbroken molecular ion would move in a circle and return to its source, but the residual nucleus has only half the mass and energy of the original particle and moves on a new circular path of half the radius, and remains. The principles of the " DCX " were demonstrated at the exhibition by means of an illuminated, three-dimensional model.

Work on linear and toroidal pinches is also under way at Los Alamos. The experiments here are more concerned with the search for an understanding of plasma physics than for the development of a thermonuclear reactor. Demonstrations of linear and toroidal pinches were given at the exhibition, and panels described the researches on plasma.



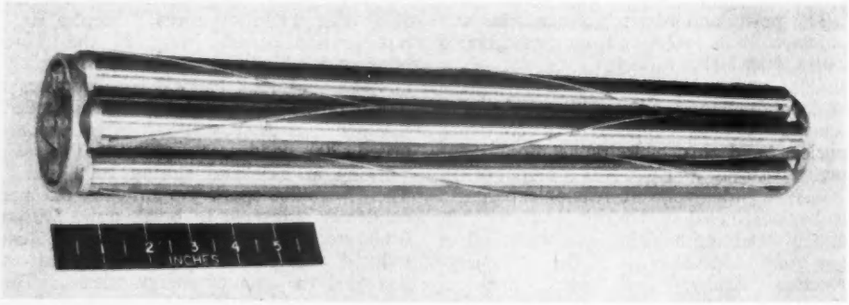
A demonstration model, part of the U.S. fusion exhibit at the Geneva Conference, which shows the magnetic field pattern of a " racetrack "-shaped " Stellarator " using " corkscrew fields." Magnetic fields of this type can be used to keep a hot ionised gas from vaporising the walls of its container

SOVIET RUSSIA

Illustrating research under the Russian reactor power programme were displays of results from measurements of neutron spectra and lifetimes in uranium-water lattices. The thermal flux in the RFT reactor was said to have been raised to $1{\cdot}8\times10^{14}$n per square centimetre per second, the fuel being enriched by 90 per cent. Fluxes up to 4×10^{14}n per square centimetre per second were reported for other research reactors. The first zero energy fast reactor, known as BR-1, was stated to have started operation in April 1955, while a 100kW fast reactor called BR-2 was built by February, 1956. The latter is cooled by mercury. These reactors, and the BR-3 fast-thermal system, were used for

‡ This was done in what was claimed to be world-record time. A team of eight assembled, tested and brought the reactor to criticality in about 500 man-hours.

§ The name arises because the electrons are moving fast enough for their mass to have increased significantly, in accordance with the Special Theory of Relativity.



Typical slug for the " NPD–2 " reactor, which is designed for on-load refuelling

TABLE I—*Russian Power Reactors*

Region	Electrical output per reactor (MW)	Type	No. of reactors in station	Stage
Voronezh	210	Water-water‡	2	Being built
Leningrad	210	Water-water‡	2	Being built
Urals	100	Uranium-graphite†	4	Being built
Volga	50	Boiling water	1	Being built
Not known	50	Graphite-sodium	1	Being built
Not known	50	Fast neutron	1	Being built
Moscow	5	Uranium* - graphite, water-cooled	1	Started June, 1954
Siberia	100	Uranium§ - graphite water-cooled	6	First reactor started work September, 1958

* 5 per cent enriched. † With superheat. ‡ Ordinary in each case. § Natural.

TABLE II—*Some Russian Research Reactors*

(*a*) Thermal

Symbol (Latin equivalent)	Charge of U^{235} (kg)	Enrichment (per cent)	Moderator	Power (MW)	Flux (n/cm^2 sec)
RFT	5·5	90	H_2O	20	$1·8 \times 10^{14}$
VVR–2	4·5	10	H_2O	3	$4·1 \times 10^{13}$
TR	5·0	2	D_2O	2·5	$2·5 \times 10^{13}$
IRT	4·0	10	H_2O	2	$3·2 \times 10^{13}$
VVR–M	4·0	20	H_2O	10	$1·1 \times 10^{14}$
VVR–TS	5·0	20	H_2O	10	$1·1 \times 10^{14}$

(*b*) Fast

Symbol (Latin equivalent)	Fuel	Reflector	Coolant	Power (kW)	Flux (n/cm^2 sec)
BR–1	Pu	U or Cu	—	0·05	—
BR–2	Pu+U	U	Hg	100	10^{14}
BR–3	Pu	U+H_2O	—	0·05	—
BR–5	Pu	U	Na	5000	10^{15}

preliminary studies, and in July, this year a 5MW experimental fast reactor was started. This burns plutonium and is cooled by sodium; the coolant temperature at the outlet is 500 deg. Cent. The results were stated to be promising, and two commercial power stations using fast reactors are projected, the first putting out up to 50MW, and the second, to be built later, putting out 250MW of electric power. Mention was made of a reactor using gaseous uranium hexafluoride as fuel, but this was very much in an experimental stage. A virtue of this principle would be its adaptability to the continuous removal of fission products. The uranium is enriched by 90 per cent in the experimental reactor, and moderation is by metallic beryllium. A power station with two thermal reactors is being built near Voronezh. Cooled by ordinary water at 100 atmospheres pressure, these reactors will burn uranium oxide clad in zirconium and enriched by 1·5 per cent. Saturated steam at over 400 lb per square inch will drive turbo-generators putting out more than 400MW altogether. A second and similar station is to be built in the Leningrad region.

The section devoted to work on the control of thermonuclear fusion showed how in vestigation had developed historically in the Soviet Union. A pulsed discharge chamber made of ceramic material reproduced the apparatus that was in 1952 observed to emit neutrons : these, like others that have since been detected in different experiments in Russia and elsewhere, were found not to be of thermonuclear origin. Photographs illustrated the "Alpha" toroidal discharge chamber.‖ This was described by Professor Emelyanov in his address to the conference as "identical to the British experimental thermonuclear apparatus 'Zeta,'" and its name had apparently been taken from the other end of the Greek alphabet as a kind of acknowledgment of the fact. "Alpha" has a torus 4·5m in major diameter and 1·5m in minor diameter. A model toroidal chamber was also shown. The linear discharge chamber¶ known as "Ogra" was represented by another model. The original has a vacuum chamber 1·4m in diameter and 20m long. Fast ions are injected and those that take part in collisions within a magnetic field are broken down. This machine thus dispenses with the arc used for the same purpose in the American "DCX" machine. The deuterium nuclei so produced are trapped magnetically as in the "DCX." The exhibits also demonstrated experimental work along other lines. Some theoretical results were displayed. One panel suggested the feasibility of converting thermonuclear energy directly into electrical form by expanding hot plasma so that the magnetic field intensity is reduced in the reacting volume and an electromotive force is induced in the coils.

Illustrating the work of the Joint Institute of Nuclear Research at Dubna (the counterpart of CERN) were a one-tenth scale model of a synchrocyclotron which, in its latest form, accelerates protons to 680 MeV ; and a one-fiftieth scale model of a 10,000 MeV proton synchroton. The synchrocyclotron also produces 420 MeV deuterons and 840 MeV α-particles. The poles of the electromagnet are 6m in diameter and the field strength in the gap under working conditions is 16,650 oersted. At present seventeen beams of various particles are used, with about fifty experimental rigs aligned to employ them. The machine works a 140-hour week. The high-energy accelerator first produced protons of 10,000 MeV in April, 1957. It is 56m in diameter. The magnet is in four quadrants, current being supplied from four generators through rectifiers ; 140MW are generated per pulse. Fifty-six pumps evacuate the chamber between the magnet poles. A 9 MeV linear accelerator injects the particles between one pair of quadrants. There are accelerating electrodes between two other pairs, and the beam is emitted from between the remaining pair.

FRANCE

An outline was given of all French activities in the atomic field. Among the subjects presented were aerial prospecting, manufacture of special materials, metallurgy, contemporary and future work on fission reactors, the use of prestressed concrete, fuelling of reactors on load, the propane bubble chamber for the "Saturne" proton synchrotron at Saclay (see illustration on page 428 *ante*) the gaseous diffusion process for separating U^{235} from natural uranium, mineral handling and treatment, instruments, and experiments on the control of thermonuclear fusion.

Selecting an example at random, the stand included a radiometric ore sorter. The prototype was shown, but a fully industrial version is now widely used and was demonstrated in a film. The display model sorted ore into three grades, rich, medium, and poor, and the grades were separated pneumatically. A scintillation counter controlled the action, and an air jet blew the lumps of ore into the selected channel. In the industrial version a mechanical arm is substituted for the air jet. Another exhibit was a scintillation counter for aerial surveying. This, combined with a pulse analyser, distinguished between potassium, uranium and thorium. Sintered materials were also displayed. BeO blocks for use in reactors are made commercially in graphite dies working at 1800 deg. Cent. and 170 kg per square centimetre. The refractories shown included mouldings in F_2Ca, ZrO_2,CaO and MgO. Cermets of U and UC were included in the exhibit ; these are made by moulding for four hours at 1000 deg. Cent. and 250 kg per square centimetre.

The 3000 MeV "Saturne" proton synchrotron particle accelerator started operation in August. The particle trajectory in each of the four quadrants has a radius of about 27ft. The magnet weighs about 1000 tons. The structure was designed to remain stable in operation within 0·0001 per cent. An excitation current of about 4450A produces a field of about 14,900 gauss which is regarded as the effective maximum. The particles are injected by a Van de Graaf generator.

CANADA AND INDIA

Canada and India are co-operating in the construction of a 40MW research and engineering test reactor at Trombay, near Bombay. The project was arranged under the provisions of the Colombo Plan. Similar in kind to the well-known NRX reactor at Chalk River, the CIR ("Canada–India reactor") is to provide facilities for training scientific and technical personnel in India. NRX, now about twelve years old, is a high-flux reactor burning natural uranium in heavy water moderator. It is cooled by ordinary water, and has been used for work ranging from fundamental physics, chemistry and biology to the engineering development of reactor parts.

Canada's own programme for the development of nuclear power was represented at the exhibition by a model of the 20MW station now being built near the Des Joachims power station in Ontario. Known as the NPD-2, the reactor is designed for re-fuelling while on load. Pressure tubes passing through it will contain the heavy-water coolant. The fuel is to be in the form of 1188 short bundles, each of seven uranium oxide rods individually sheathed in zirconium alloy. Adjacent channels will be fed from opposite ends. The illustration on page 448 shows a typical "slug." Control and emergency shut-down will be entirely by alteration in the surface level of the heavy-water moderator, and no moving solid absorbers will be needed in the reactor. The level of the moderator surface will be regulated by helium gas pressure, and the system is designed so that failure, should it occur, is safe. The station is scheduled to be working in 1961 and is intended to serve as a prototype for a later 200MW plant.

‖ See illustration in No. I, THE ENGINEER, September 12, 1958, page 409.

¶ A photograph of this device was reproduced in No. I of this account (see THE ENGINEER, September 12, 1958, page 409).

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

CROYDON AIRPORT

SIR,—The decision of the Ministry of Transport and Civil Aviation to close Croydon Airport causes my co-directors and myself considerable concern. Our company, and many others operating private aircraft specifically for the purpose of furthering home and export business, must have the use of an airfield near London in order to operate with speed and efficiency.

With the closure of Hendon and Northolt, Croydon is the only airfield available to us which is within easy reach of London.

Apart from this, Croydon Aerodrome is regularly used by commercial operators, by ambulance services, by the Press, by flying clubs, and, ironically enough, by the R.A.F. and U.S.A.F. as an alternative landing ground when poor weather conditions prevail at Gatwick.

So far no suitable alternative is proposed. Surely the Minister of Transport and Civil Aviation should think again before prejudicing the efficiency of industries already handicapped by bureaucracy, and hamstrung by taxation.

DAVID BROWN, JNR.,
Director and General Manager.
David Brown Industries, Ltd.,
Huddersfield,
September 10, 1958.

WORKS TRAINING FOR ENGINEERS

SIR,—May I send you, rather belatedly, a reply to your mention (but not by name) of this Group Training Organisation, in a leading article entitled "Works Training in Sandwich Courses" in your July 25 issue. You mention two points with which I will deal separately.

"But we rather wonder how satisfactory such schemes are." Scottish Electrical Training Scheme, Ltd., is, we believe, the only organisation of its kind in the United Kingdom. It has eight members (five manufacturing, two supply boards and one in electrical contracting), and they come under the heading of "medium sized firms," each of which finds it difficult, if not impossible, to provide fully satisfactory practical training for those about to become professional electrical engineers. Between them they can and do provide a very broadly based training programme meeting the requirements of the Institution of Electrical Engineers for graduate training and for the vacation training which leads up to it. Clearly it will be several years before the success of such a scheme can be accurately measured against its cost. It is only after, perhaps several years after, the men trained in S.E.T.S. have joined our members that the value of a comprehensive training scheme can be assessed. This fact was fully realised by the organisations, firms and electricity boards, which established S.E.T.S. We do claim, however, to have made a successful start. Although this is only the second year of our operations, we have training with us this summer over 100 men, counting both graduates and those doing vacation training. We have had to refuse many applications from lack of training vacancies.

"For where do the students' roots go down?" The short answer is that we believe they go down both ways. Not only are our men glad to belong to an organisation giving them training in heavy current manufacture, light current manufacture, cable making, all aspects of the electricity supply industry and in electrical contracting, but we believe that they have already acquired a considerable *esprit de corps*. An example of this is that they are themselves asking us to produce a S.E.T.S. tie. None of our trainees decides which member he is going to join until the end of the first year of graduate training, yet we note the keen interest which they take in the doings of the member with which they are training at any particular time. We encourage this interest by issuing a house magazine which includes news from all our eight members.

J. E. C. MCCANDLISH,
Organising Secretary.
Scottish Electrical Training Scheme,
127, St. Vincent Street,
Glasgow, C.2,
September 5, 1958.

RAILWAYS INTO ROADWAYS

SIR,—I think your journal is to be congratulated on continuing to publish correspondence on the above subject over such an extended period. The fact that letters continue to be received indicates the intense interest the matter has aroused in your readers. Summarising the correspondence, the opinions expressed are about fifty-fifty for and against conversion, with perhaps a slight lead "for," but there is certainly no argument put forward, so far, which has completely demolished Brigadier Lloyd's theory. May we then assume that there is not one? Therefore, Sir, I suggest that the time has arrived for some bold action to be taken by the Government. Time for the spirit of Churchill or Disraeli to enter one of our leaders, for him to say, "We will notify the B.T.C. that we propose to take the old Gt. Central line from Sheffield to Rugby and turn it into a high-speed, toll motor road and pay you so many millions for it."

This proposal would link steel and coal with the industries of Nottingham, Loughborough, Leicester and Rugby; it would not cut off any of these towns from the railroad as they all have stations on alternative routes. It would provide the B.T.C. with some ready cash instead of having to borrow from the Treasury, it would provide almost immediately a large piece of the proposed London–Yorkshire motor-way, and it would give opportunity for a full-scale test of Brigadier Lloyd's plan. Even if the carrying capacity and speeds envisaged by the Railway Conversion League were not realised this scheme would not be a dead loss as the country would still possess a good new highway.

A committee of three top flight experts, a civil engineer, an accountant and a leader in road transport should be charged with the preparation of the "blueprint" of the scheme, and the amount to be paid to the B.T.C. for the entire property, the report to be completed in a given time, say six months from the word "go." Let the Government then put forward a Bill, get it passed and the work started. Then the country would know that we had some leaders of spirit, not afraid to tackle a problem courageously, not content to fiddle with it as in the past. I have a feeling they would prove to be right, otherwise this letter would never have been written.

"CONCRETE"

Derby,
September 6, 1958.

SIR,—The main argument for turning the railways into roads is apt to get lost in a welter of detailed statistics. The broad case for conversion is quite simple. By 1962 some 10,000,000 motor vehicles will be choking up our 30,000 miles of class I and trunk roads. We can only add 120 miles a year, at great cost and grievous damage to our countryside. Our 20,000 miles of railway is lightly used by about 1,000,000 rail vehicles. If this permanent way were turned into roads their work could be done better, quicker and cheaper by less than 50,000 motor vehicles. Except at rush hours near London they would hardly be noticeable. Nearly the whole 20,000 miles of new first-class roads would then be available for through and fast motor vehicles. The main traffic problem of the country would be solved with immense benefits to all.

In 1943 we launched Operation "Overlord" to relieve Europe. We now need operation "Overlloyd" to set our road traffic free before it comes to a grinding halt.

H. E. MORSE

Weymouth,
September 2, 1958.

SIR,—I can assure Mr. E. B. Parker (August 8) that I was most sincere when I said I would be willing to help form an Anti-Railway-Conversion League. It has, however, been pointed out to me that this is unnecessary as such a society already exists—namely, the Railway Development Association.

This organisation was founded in 1951, when almost every week a branch line was being closed and many people were wondering where the contraction policy would end. Since then, it has assisted many local councils in their fights against the Transport Commission by showing that the railways still can, under certain conditions, offer a more attractive and economical service to the community than road transport. Plans have

been drawn up by the Association showing how existing lines can be much better employed to the public benefit with the minimum of capital expenditure. It states that the drift of traffic from rail to road has been due to the big progress in the development of road vehicles of all kinds and the comparatively little progress made by the railway concerns over a period of many years. It believes that a properly integrated system of road and rail transport should be possible. Bus and railway stations should, where possible, be located at the same spot (e.g. Harrogate) and not at opposite ends of a town (e.g. Salisbury). Bus services should run in conjunction with rail services and not seek to vie with them to the detriment of the public.

In severely congested areas such as London, where road traffic is getting so dense as to threaten serious chaos, the Association recommends that a concerted effort be made to get as much passenger traffic as possible off the roads and on to the rails, and for this reason such projects as new tube and overground railways and the fullest use of existing railway tracks are fully supported. I am joining this organisation because I believe no form of road transport can surpass properly designed and operated rail vehicles for comfort, speed and for efficiently handling heavy traffic. Further information about the Association can be obtained from The Hon. Secretary, Mr. P. Eavis, 123B, Central Road, Worcester Park, Surrey. Viscount Garnock is president, John Betjeman and Robert Aickman are vice-presidents.

DENNIS GILL

Hazel Grove,
Cheshire,
September 5, 1958.

Book Reviews

Henry Edward Armstrong. By J. VARGAS Eyre. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 30s.

AMONGST the great pioneers of technological education Henry Edward Armstrong will always hold an honoured place. A man of vision, of robust common sense and of inexhaustible energy, he appears at an early age to have appreciated the important role that science could play in improving industrial methods and in increasing industrial efficiency ; and throughout a long life he pursued with singleness of purpose the promulgation of his views.

He began his active life at a period when English industry was with difficulty seeking to maintain, against increasing competition, the dominating position it had long held in world markets ; and to understand his contributions to technological education one must visualise the atmosphere of mid-Victorian England in which he grew up. It was a time of material prosperity, of immense expansion in trade and commerce ; it heralded the beginnings of universal education and of social services ; it marked the peak of individual enterprise and of colonial development.

Armstrong received his early education at the Colfe Grammar School, an ancient foundation of the Leather Sellers' Company and later at the Royal College of Chemistry when he attended lectures by Huxley, Hofmann, Frankland, Ramsay and Tyndall. He subsequently spent two years at Leipzig working under Hermann Kolbe. In those days a student had much greater freedom of choice in the subjects of his study than is customary to-day and Armstrong took full advantage of this circumstance to pursue a course including chemistry, geology, botany and agricultural science. The diversity of his interests was at once the strength and weakness of his character and, in spite of his devotion to scientific research, he could never bring himself to adopt that narrow specialisation which was then becoming the fashion in Germany and which has since led to such spectacular advances in the physical and biological sciences.

On returning to England in 1870, Armstrong was appointed to the Chair of Chemistry at the London Institution. There his students were artisans and apprentices drawn from many local industries, and the problem of devising a course in chemistry which would satisfy their varied needs called for innovations which were by no means distasteful to his original mind and advanced views. His methods began to attract attention, and when in 1879 the City and Guilds of London founded an Institute for promoting technical education, he was invited to become lecturer in Applied Chemistry. Later he was appointed to the Chair of Chemistry at the City and Guilds Central College, a post he held until he retired in 1912.

Although at the time of Armstrong's appointment to the Central College the industries of this country were rapidly expanding, the only technologists employed by them were engineers and even in the heavy chemical industry it was thought unnecessary to have more than one analytical chemist on the staff. To Armstrong belongs the credit of appreciating the need for engineers of a new type with more than a superficial knowledge of the physical sciences. He met with considerable opposition.

For nearly thirty years Armstrong carried on the fight with varying success, but his views were in advance of his time and it was not until after his retirement that, as the result of the first world war, the absolute necessity for training chemical engineers was universally recognised.

But Armstrong was not only a pioneer of technical education, he was also a great teacher. He insisted that the training of a scientist should be through the laboratory and that the method should be based upon original inquiry and practical experiments. He was himself an assiduous research worker and many of his old students can still vouch for the exciting quality of his instruction and the spirit of adventure which characterised his courses.

From the date of his retirement in 1912 until his death in 1937 Armstrong kept in close touch with scientific and industrial progress. He travelled widely, took an active part in scientific discussions and was keenly interested in following the researches of the younger generation of scientists.

We recollect vividly the visits of Armstrong to a certain laboratory in the inter-war years. The acerbity of his character had by that time mellowed with age ; but there were about him hidden fires and rumblings and formidable reserves of invective which were both impressive and at times alarming.

In this book Dr. Vargas Eyre, one of his old students and his biographer, writes of him with affection and understanding. He draws a vivid picture of a man of intellectual vigour, of original and creative mind and of tenacity of purpose. We see him with his family background, waging a constant war in the cut and thrust of debate, and dedicated against the forces of reaction, taking a delight in a great cause.

Advances in Steel Technology in 1956. United Nations Economic Commission for Europe. European Office of the United Nations. Geneva : Obtainable from the Sales Section, European Office of the United Nations, Geneva, Switzerland, or may be ordered through Sales Agents for United Nations Publications, H.M. Stationery Office, Retail Mail Order and Wholesale Department, P.O. Box 569, London, S.E.1. Price 7s.

THE fifth and last series of reports on recent advances in steel technology has just been published by the United Nations Economic Commission for Europe (ECE). It is unlikely that similar reviews of this subject will be published in future. The progress made by the ECE Steel Committee in the last two years in promoting all-European technical contacts, together with the growing exchange of scientific and technical documentation on the iron and steel industry, suggests that reviews of this kind are less necessary than they were a few years ago. Furthermore, in other reports since prepared by the ECE Secretariat for the Steel Committee, special attention is paid to the economic aspect of the major technical advances. The articles included in this report have been selected by the Steel Committee, because they are the hitherto unpublished work of recognised specialists, and because they deal with processes capable of industrial application and examine their economic implications and advantages. The introduction is by Professor I. P. Bardin, an Academician of the Soviet Union, who reviews the position of the steel industry in 1956.

Optique de la Photographie Sous-Marine. By CLAUDINE MAUREAU. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.74. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, [Paris (15e). Price Ffr.1800.

THE present monograph is concerned with the design of photographic lenses for underwater use, the front surfaces of which are in contact with the water. When submarine photographs are taken through plate glass windows, the field and depth of focus are much reduced, disadvantages not shared by the immersion lens. The cases considered here are the single Wollaston lens, two-component lenses, and an outline of the theory for triplet lenses.

Books Received

Motor Cycles. Part 2. By C. F. Caunter. H.M. Stationery Office or the Science Museum, South Kensington, London, S.W.7. Price 7s. 6d.

Business Enterprise : Its Growth and Organisation. By R. S. Edwards and H. Towsend. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 60s.

Jahrbuch der Elektrowärme, 1957. By Harald Muller. Vulkan-Verlag Dr. W. Classen, Haus der Technik, Hollestrasse 1g, Essen, Germany. Price DM58.

Design and Operation of Low Pressure Acetylene Generators. The British Acetylene Association, Carbide House, 55, Gordon Square, London, W.C.1. Price 7s. 6d.

Introduction to Nuclear Engineering. Second edition. By R. Stephenson. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 74s.

Basic Electrical Engineering. By J. Shepherd, A. H. Morton and L. F. Spence. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 27s. 6d.

Baroque Tendencies in the Evolution of the Gravity Dam

By SERGE LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. I

The author begins by outlining an analogy between the style, which in the history of art is described as "baroque," on the one hand, and the "buttress" or "hollow" type of dams, on the other. The pros and contras of this last type are then considered, both as regards technical advantages, and war risks. Three stages in the historic evolution of the type are illustrated by means of examples, starting with the Theresa dam (1903) *and ending with a number of works which have just been completed, or are still under construction. The stress analysis characteristic of the type is outlined and the advantages of various modern improvements assessed.*

THE term "baroque" belongs primarily to the theory, or history, of art, and is seldom—if ever—used in technical engineering publications. The fact that it appears in the title of this article deserves, therefore, being more clearly explained.

In the first instance, what does this term actually mean? Curiously enough, there does not seem to be full agreement on the subject. Take, for instance, *The Encyclopaedia Britannica*. On page 424 of the third volume (eleventh edition) we are told that the word baroque "indicates the more extravagant fashions of design that were common in the first half of the eighteenth century, chiefly in Italy and France, in which everything is fantastic, grotesque, florid or incongruous—irregular shapes, meaningless forms, an utter lack of restraint and simplicity. The word suggests much the same order of ideas as rococo." If, now, we consult the article bearing on this last term, i.e. rococo, which appears on page 436, Vol. XXIII of the same edition, we are informed that it was "a debased style at the best, essentially fantastic and bizarre," and also that "the very exuberance of the rococo forms is, indeed, the negation of art"; and so on, in the same order of ideas.

The surprising shortness of these articles, dealing, as they do, with a style which, originating in Italy in the end of the seventeenth century, permeated all Europe, and for more than a century affected the destinies of architecture, painting and internal decoration, enhances the crudeness of the condemnation they contain.

Let us now consider another expert opinion on the matter, as expressed in the relevant texts of Sir Banister Fletcher's classical treatise, "*A History of Architecture* . . . ," which is, possibly, one of the best English books ever written on the subject. In a "General Sketch of its Genesis" (page 545, seventh edition), Sir Banister says that the baroque "arose in the seventeenth century, when the true Renaissance had exhausted its energy and succumbed to the formal rules and monotonous regulations of schoolmen and Classicists." He further says: "The Baroque was perhaps chiefly the outcome of reaction against the blind worship of Vetruvius, the Roman architect of the Augustan age, who had laid down rules, and whose latter-day sixteenth-century disciples handed out prescriptions for building, which killed the vital spark of the true Renaissance spirit. Thus, when the spirit of art, which giveth life, had died down, schoolmen and Classicists sought to revive it and to bind it on the nation by insisting on the letter of the law, which killeth. But the men of the free cities of Italy loved freedom and would not submit to the dead hand in art. The bookish formality in design had tended to reduce architecture to a lifeless product, uninspiring in aspect, against which it is not surprising that the beauty-loving Italians should, after a time, have risen in revolt. They were weary of lifeless conventions and they rose against the tyranny of stereotyped rules and standards of proportion. They demanded freedom—freedom in plan, in design, and in ornament. Thus, in the fulness of time, the Renaissance style suffered a new change and passed into the Baroque, which at the beginning of the seventeenth century gave expression once again to the human side in architecture, for it was a spontaneous breaking-away from orthodoxy in plan, design and treatment."

This, it will be conceded, is an entirely different "son de cloche" from that which appears in the Encyclopaedia. Now, why should there be such a fundamental inconsistency in the respective approaches to the same subject, as outlined in two highly authoritative publications? An exhaustive reply to this apparently simple question might have required an equally exhaustive analysis of the deeper reasons of the conflict; which, however, is obviously beyond the scope of this brief incursion into the domain of the history of art. It will suffice, however, for our purposes, to mention one fact only, of the relevant history, in order to give a glimpse of the forces which motivated the controversy about the merits of the baroque style; namely, that it happened to become patronised by the order of Jesuits, to such an extent that it was known, at the time, as "the Jesuit style." This explains at least one point, viz. the antagonism of a large part of public opinion, for whom anything bearing upon, or related with, the Jesuits, was (and still is) *ipso facto* anathema.

In the title of this article, the term "baroque" is used in this, Sir Banister's, sense. The application to dam design is then easily made clear.

Genesis of the Baroque Style Dam

Some hundred years or so ago, the Frenchman, Sazilly, applied Navier's rectilinear stress diagram to the calculation of masonry dams, and thus produced the first design of the so-called "gravity" type, i.e. the Gouffre d'Enfer dam. Thereafter followed a period when numbers of progressive designers used their ingenuity to develop various new types belonging to the same category of designs. But, as time went on, it naturally occurred that this class of works became gradually standardised, and this became true to such an extent that the engineer had only to draw two intersecting straight lines, in order to obtain the profile of such a dam; the angle enclosed by these lines remaining almost always the same, in all the modern projects of that description.

Here, again, as in the history of the baroque style, personal initiative and love of freedom were responsible for causing a fundamental break with the universally accepted traditional methods adopted in the design of gravity dams. This break was achieved by the repeated use and manifold applications of the principle of the "hollow" dam (from the French term: "barrage évidé").

The terms of the foregoing sentence are not intended to mean that the principle in question is a new invention. The fact is, that it was first used as early as 1903, in a dam built at Theresa, in the U.S.A., by Nils F. Ambursen; and it was subsequently applied in various other works of the same type, during the earlier part of this century. The difference, however, is that in the majority of these earlier buttress dams, the constructional works were divided into two parts, relating, respectively, to the light deck carrying the water pressure, and the heavy buttresses on which this deck rested; whereas in the new type, which was introduced into the everyday practice more recently, deck and buttresses (of whatever description they might be) constitute a monolith, every part of which is built concurrently with, and contributes to the stress-carrying capacity of, the whole.[1]

The analogy with the circumstances which started and later controlled the historical development of the baroque style in art—as outlined earlier—is emphasised by the fact that all these new dam types—whether of the earlier or later periods—while they break with the routine of the consecrated traditional standards, afford, at the same time, a wide field of opportunity for the application of a designer's own initiative and genius; whereas under current design regulations, all that is required from an engineer when he attacks a project for a classical gravity dam, is a certain ability in manipulating the "frozen," ready-made rules of proportion relating thereto, and constituting the heritage of the earlier generations of designers; which rules are, however, completely upset by the introduction of the new technique of the "hollow" dam.

Pros and Contras

It must, of course, be conceded, that, whatever its other advantages and attractions may be, the primary object in adopting this original structural type, is to attain economy. In fact, in spite of a generally lighter horizontal section subject to bending, the stress-intensities may be (and are) reduced by using a "special" profile; in the same sense as, *ceteris paribus*, an I-beam (for an equal weight of the same material) carries a larger load than a plain rectangular section; and because, in spite of a smaller sectional area, the second moment (and, hence, the section modulus) for the more elaborate shape is relatively greater. This contingency enables a daring designer to devise a section which suits best his purposes, and, by these means, to achieve economy; in addition to which there are other advantages which will be described later on in these pages.

But, the problem of sliding safety, since it depends essentially on the vertical weight imposed on the foundation, cannot be solved in the same simple and easy manner. In this case, we take advantage of another stratagem, viz., instead of being almost vertical, as in the traditional profile of the classical gravity dam, the front face is designed heavily inclined, and thus, all the water superimposed over this face, comes to help

[1] In some of the dams of the earlier period, particularly those built in America, the light arch, though built separately from the buttress, was nevertheless included in calculating the section modulus of the latter, but such practice was strongly objected against (see Kelen, *Die Staumauern*, Berlin, 1926, page 173).

us, in increasing the vertical resultant acting on the foundations. In this manner the vertical component of the hydrostatic force stands *in loco* of the structural weight, and the ratio of vertical to horizontal forces is still sufficiently high for ensuring ample stability against sliding and shear.

It will be observed that in the foregoing explanation the term "economy" in the monetary sense is implicitly assumed to be synonymous with "economy of material." Such an interpretation is, however, not necessarily correct, particularly in relation to the works belonging to the earlier period of buttress dam construction, for the unit prices for the light decks embodied in that design were always higher than those in common use for mass concrete employed in the usual gravity dam; and, in general, all the work in these buttress dams was relatively more expensive, because of a larger area of cofferage per unit volume of finished

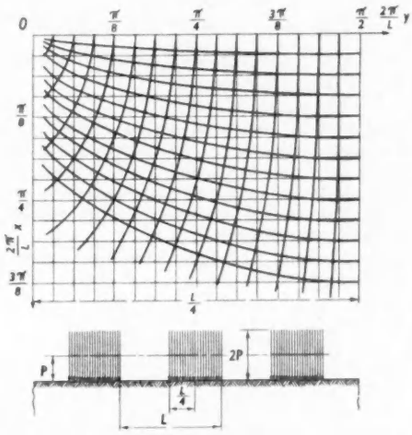


Fig. 1—Stresses in an elastic rock foundation beneath a buttress dam

concrete. The economy (if any) achieved in using the earlier types of buttress dams was, consequently not as great as might have otherwise been possible.

It is, in fact, this particular aspect of the problem, which renders the latest form of "hollow" dam particularly interesting and attractive to the designer and builder. In this connection, significant information is yielded by the figures quoted by Dr. Claudio Marcello. For instance, in a paper published in the *Schweizerische Bauzeitung*, in 1950,[2] he states that the reasons for the differences of unit prices for the plain gravity dam and the hollow dams are chiefly as follows.

(*a*) Assuming that plain concrete in an ordinary dam of the current type is cast in blocks of 10m×10m, the area of cofferage per cubic metre of material, may be as much as four times greater in a buttress dam, than in a plain gravity dam (in the type described earlier as "hollow," this ratio is, of course, very much less and may be a matter of only a small percentage).

(*b*) The horizontal area of fresh concrete during the casting operation is smaller and its shape is more involved in the new types.

(*c*) The percentage of cement in the concrete, broadly speaking, must, in these types, be greater.

Notwithstanding all of which, according to actual quotations for some of the dams recently built by the author (the Trona and the Bau Muggeris), the differences in unit prices amounted to a few per cent only; so that, with economies in the volumes of the materials as high as 27·5 per cent and 40 per cent, the respective savings in the total costs of these two dams were 24 per cent in one case, and 35 per cent in the other. In addition to which, various other advantages were also attained, according to the same source, as follows:

(*a*) A material reduction—and in certain cases, complete absence—of uplift, i.e. interstitial pressure in the pores at the base of the profile.

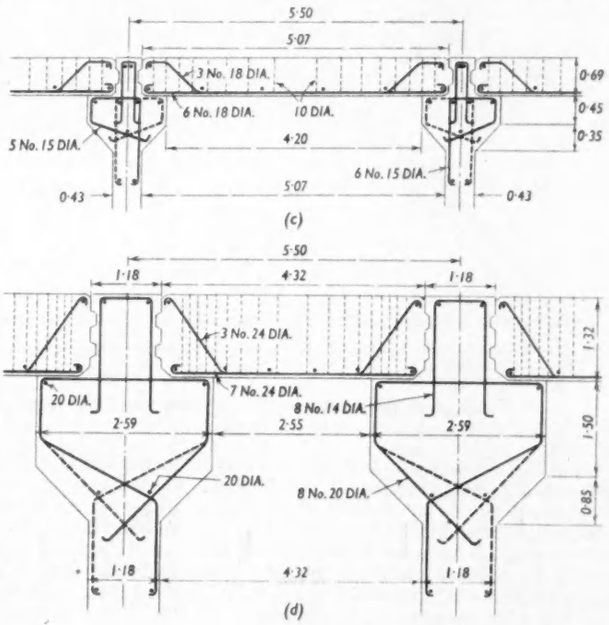
(*b*) The ease with which the initial chemical temperature rise may be allowed to flow outward.

(*c*) Under some conditions shorter construction period, consequent on a smaller amount of concrete to be cast. This last advantage may, however, be of doubtful value, if the more involved methods of work call for a longer construction period.

On the other hand, the objections raised against the new type are both of a general, and, also, of a technical, character. The former centre on the greater vulnerability of the hollow dam (in time of war) as compared with a plain dam, and in fact, in certain countries existing hollow dams have been filled in, for reasons such as those stated above. Mr. Marcello[2] (*loc. cit.*) gives apparently sound reasons, militating against such extreme views. The question, in such cases, is to keep a proper balance between the war risks as such, on the one hand, and the peacetime interests of the population, on the other. For, should too much attention be devoted to the former, we might arrive at incongruous conclusions, such, for instance, as that all bridges should be replaced by tunnels, because the latter provide a better protection against bombs dropped from aeroplanes.

Discontinuities in Foundation Pressure

Turning, now, to the second group of objections—those based on technical considerations—it seems that the main (and only) point of adverse criticism relates to the effects (if any) of the discontinuity of the load imposed on the foundation, and to the shearing stresses resulting therefrom. According to the same author (*loc. cit.*) the structural section of the firm Gruppo Edison, in Italy, carried out a special theoretical investigation,



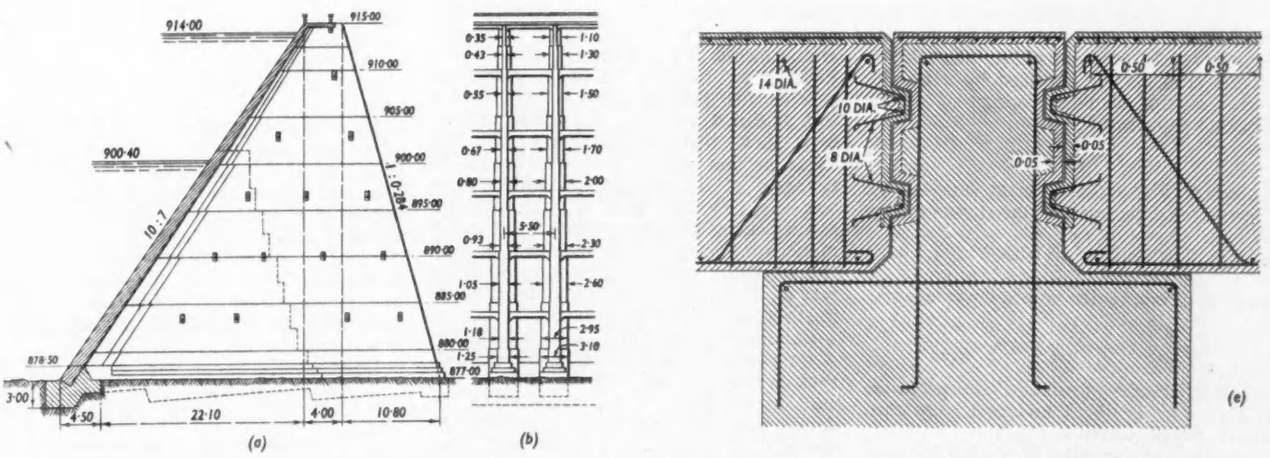


Fig. 2—Combamala flat-deck buttress dam. (*a*) Profile of dam. (*b*) Back elevation of the dam. (*c*) Details of the slab of Combamala dam, upper part, (*d*) lower part. (*e*) Arrangement of the bearing of the deck in Combamala dam

[2] "Moderner Talsperrenbau in Italien," Nos. 33, 34 and 35, 1950.

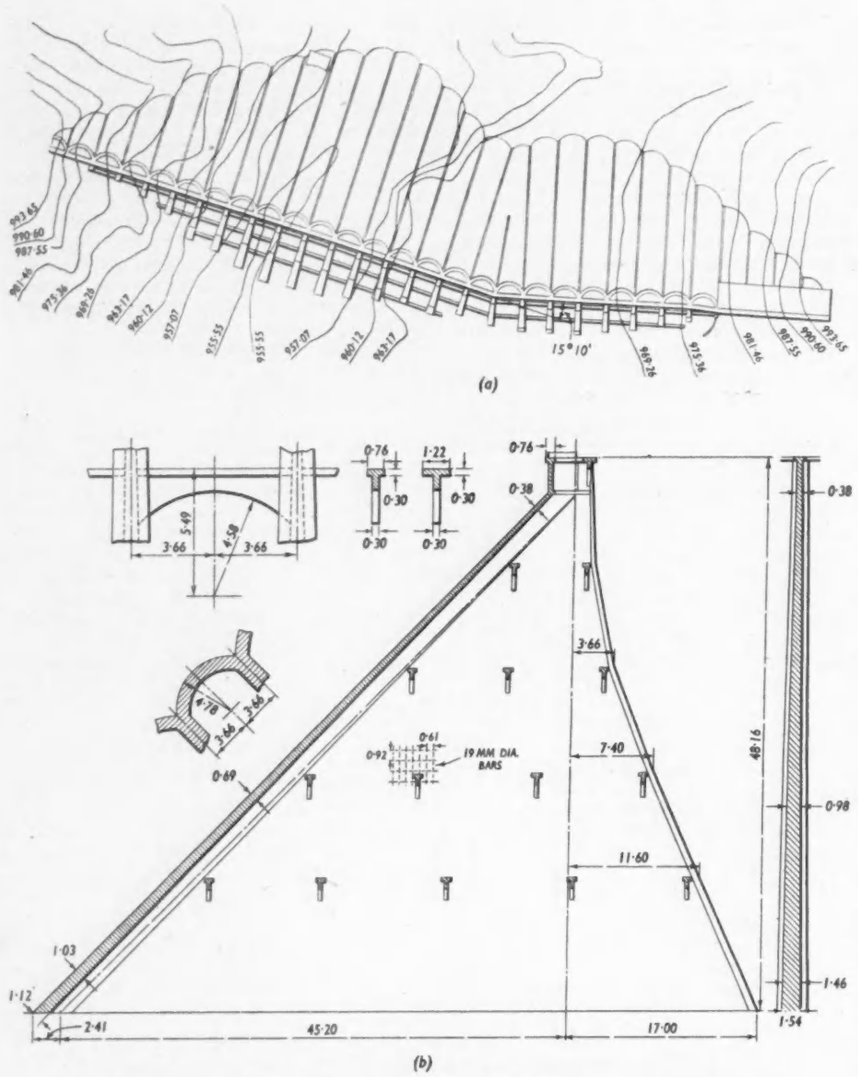


Fig. 3—Palmdale multi-arch buttress dam. (*a*) Plan. (*b*) Profile and details

in order to throw more light on the alleged dangers of discontinuities in the foundation pressures. A semi-infinite elastic plane was postulated and the corresponding loading was assumed to be in the form of waves, i.e. an infinite series of uniformly loaded strips, the individual widths of which were $L/2$, and the unloaded widths of the intervals in between which were likewise $L/2$ (as shown in section in Fig. 1).[3]

The average unit load was equal to p, but its local intensities varied from 0 in the unloaded intervals to $2p$ under the piers. The solution of the problem was obtained by a Fourier series, starting with the concept of a load diagram represented by

$$p = p_0 \sin(wy)$$

(in which y was the ordinate and $-x$ the abscissa) and ending with the stress function

$$\Phi = p_0 \frac{wx+1}{w^2} \sin(wy) e^{-wx}$$

from which can be determined the values of

$$\sigma_x = \frac{\delta^2\Phi}{\delta x^2}\ ;\ \sigma_y = \frac{\delta^2\Phi}{\delta y^2}\ ;\ \tau = -\frac{\delta^2\Phi}{\delta x \delta y}.$$

The trajectories of principal stresses in the critical zone of the foundation were then found to be as shown in Fig. 1.

Attention will be called, in the first instance, to the fact that the diagram is the same for both the loaded and unloaded sections ; but, of course, in one case the stress varies from 0 to the average, whereas in the other case it rises from the average to the maximum. Particular interest centres, also, on the fact that the curves in the unloaded section assume the form of arches, which is believed to be symptomatic of an effect known, generally, as "arching." This conclusion could be interpreted as a useful hint to the designer, in connection with the choice of his structural arrangements, e.g., inverted arches, &c. Finally, as regards the most dangerous zone at the meeting point of the loaded and unloaded stretches, numerical calculations show that the maximum shearing stress in that region does not exceed 60 per cent of the average foundation pressure—i.e. 30 per cent of the pressure existing under the piers—which is scarcely a matter for concern. But, such as it is, even this moderate shearing stress may be taken care of, by means of inverted arches, expanding footings and similar devices.

Conditions might, of course, be different if we assume a heavily sloping (or stepped) rock surface, as will, for instance, be the case on the flanks of the valley which the dam is spanning. But this is a problem the solution of which may contain perplexing points in dealing with many other types of dams also, and which does not, consequently, point at any specific defect of the "hollow" dam, as such.

[3] Reproduced from Dr. Marcello's article in the *Schweizerische Bauzeitung* quoted earlier.

Types and Periods

Turning, now, to broader issues, the reader may be interested to obtain a general picture of the various ramifications of the basic baroque tendency. An attempt is, consequently, made below, to classify the various individual types belonging to this group.

We have already intimated that there were two fundamental classes representing the older period and the latest advances, respectively. If this basic division were to be amplified so as to form a self-contained, consistent system of classification, a third, intermediate class should be added, and we would then obtain the following arrangement, reflecting the gradual evolution of the original "baroque" concept :

(*a*) The earlier period.

(*b*) The more mature, but, nevertheless, already outmoded, types, and

(*c*) The latest developments in this category of works.

Each of these three main divisions will now be considered individually.

(*a*) The earlier period includes a very large variety of different designs, belonging either to the flat deck (i.e. slab) group, or to the multi-arch type, as exemplified respectively in Figs. 2(*a*) to 2(*e*), and 3(*a*), and 3(*b*)[4]. It should be realised, however, that the number of arrangements used in those early works was almost infinite, and that these two examples are examples only, and must not be interpreted as an attempt at an exhaustive characteristic of the period.

For instance—taking first the flat type—the deck was either built of independent and articulated reinforced concrete slabs, or it belonged to the massive-buttress class, without any reinforcement carrying calculable stresses. (Curiously enough, the principle embodied in this last sub-class, was a step forward towards the much more modern principle of a deckless buttress dam). The same remark on the diversity of designs applies also, and possibly to even a greater extent, to the multi-arched category, for here, again, the arches were either built of plain concrete, or were reinforced, and so on.

The arrangement of the buttresses and their bracings were another detail which was subject to much variation. In certain cases (Austin dam in Texas) the usual buttresses at right angles to the main axis of the dam, were supplemented by longitudinal walls which rendered the cost of this dam so great that no one dared to attempt the device again.[5] In other cases the buttresses were replaced by a "a series of inclined columns, terminating in spread footings on the foundation, and carrying on their tops or upstream ends a heavy inclined girder, which supported the deck slabs."[6] This arrangement was known as "columnar-buttress dam," and appears to have been due to W. S. Morton ; and again, in the "truss-buttress" dam, the columns themselves were replaced by a reinforced concrete truss. Apart from that, another design was also proposed (and successfully attempted) in which there were neither slabs nor arches, but domes. This was exemplified by the well-known Coolidge dam, in Arizona, a marvel of engineering genius and daring.

[4] Abstracted from the already quoted work of Dr. Kelen (see footnote [1]). This book, i.e. *Die Staumauern*, Berlin, 1926, Julius Springer, Ed., is particularly recommended to the designer's attention, for it contains numbers of useful curves giving the economical spans and thicknesses of buttresses, arches, slabs, &c.

[5] *Handbook of Applied Hydraulic*, collective work under C. V. Davis, Section 6, by E. H. Burroughs, page 197.

[6] *Ibid.*, page 198.

From perusing this brief résumé, the reader must be convinced that the word "baroque" supplies, indeed, an appropriate definition for the structural tendency here considered, and that the use in an engineering study, of a term belonging to the history of art, paradoxical though it might appear at the start is, nevertheless, fully justified by the specific characteristics of the case under review.

More Mature, but Already Outmoded Types of Class (*b*)

It must be understood that the classification method outlined in these pages, is by no means based on the chronological principle, but it is intended to reflect the successive stages of the technical evolution of an idea, which led ultimately to the development of

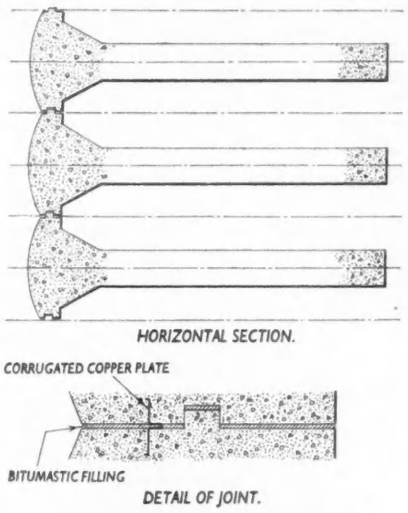


Fig. 4—Mushroom-head buttress dam

the modern concept of "hollow" dams. It might, therefore, occur that some of the works included in this second group have already, to their credit, a useful service period of more than twenty years, whilst others are still in course of construction. They have, however, one common characteristic, namely, that all of them are less "nervous" than the first group, and display a more realistic understanding of the expenses involved in bringing into being various more-or-less extravagant brainwaves.

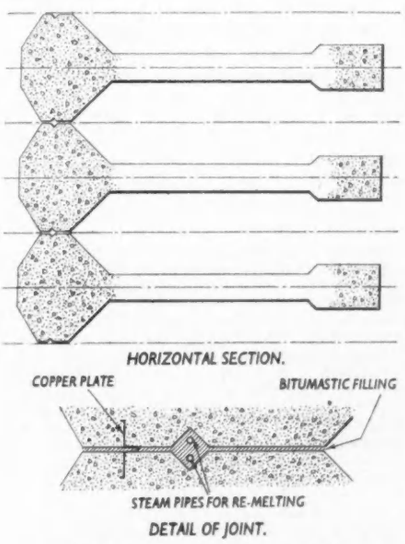


Fig. 5—Diamond-head buttress dam

In the first instance, we may cite, *en passant*, a principle suggested and patented by Mr. F. A. Noltzli. It consists, essentially, in using buttresses provided with two parallel webs, with a hollow space in between them (8ft in the Bartlett dam and about 20ft in the Pensacola dam). The reason for quoting this solution is that it is a transition step towards the double-web units, typical of the third group. But the distinguishing characteristics of the bulk of the works here assigned to the second class, is the complete absence of any solid contact between the individual buttresses; i.e. each buttress in such a dam constitutes a self-contained unit, resisting against the hydraulic pressure applied to the front face of its head (which is widened out for this purpose), and has, thus, no other contact with its neighbours, except for a thin flexible diaphragm, or metal plate, which performs the duties of a seal for the open joint (see Fig. 4) between the contiguous faces of every pair of buttress heads. To ensure better impermeability all the empty spaces in such a joint, are usually filled in with various bitumastic substances, which are occasionally provided with special devices for periodical re-melting. In certain instances, e.g. the Glen Shirah dam, in Scotland, the heads of individual buttresses are spaced 5ft to receive a wedge-shaped section, which is poured when the main buttresses are already raised to considerable height; but this is by way of an exception.

The different sub-classes belonging to this general group are usually designated according to the geometrical shape (in section) of the head, characteristic of that particular subclass; thus, we distinguish between mushroom-head buttress dams (as in Fig. 4), diamond-head buttress dams (as in Fig. 5), &c. One of the essential points in the design of this category of dams is, that the head is included in the calculation of the stability of the buttress, whereas in the earlier period, this constituted a rather dubious point, which was the subject of much controversial discussion. In fact conservative continental views were at that time very much against such a practice, for the light decks (whether made of slabs or arches) were usually built of an entirely different material and at a much later period than the main body of the buttress, and the assumption of a consistent, linear stress distribution over the entire length of the structure had therefore no support in reason at all.

Thus, the characteristic feature of the second group is, primarily and essentially, the concurrence in time of the construction of all the parts of the entire work, and the use of the same material. It follows therefore that the stress analysis must be adjusted accordingly, i.e. in calculating the bending and shear effects on horizontal sections, we must take into account that these sections are no more rectangular in shape—as had been the case with either the plain gravity dam, or with the buttress dam of the first category. In other words, this conclusion means that the so-called "middle third rule" is not applicable to the dams now considered, and that this rule must therefore be replaced by another method, which takes into account the true geometrical shape of the section, with its characteristic widenings at the head and tail, and the narrower web in the middle. This applies, of course, to both bending and shear stresses, and all other stresses coming into consideration.

(*To be continued*)

Australian Aeronautical Research

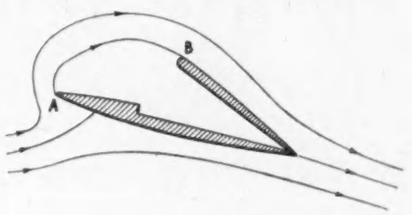
THE report for 1956–57 of the Department of Supply Aeronautical Research Laboratories records that during the year the programme of work was reviewed and its scope extended to include appropriate aspects of guided weapons. Much *ad hoc* work was performed—for instance, improvement of the Royal Australian Navy target streaming gear of a "Firefly" to handle the S.A.A.B. hit-and-miss recorder, assessment of an Aden gun installation in a "Sabre," and aerodynamic investigations on a helicopter being developed by a local firm. It is believed that these diversions from basic research add to the difficulty of maintaining a high quality scientific staff and will impair the capability of the laboratories.

Aerodynamics.—Further work on the control of boundary layers is reported; air jets, which when circular holes were used were not as effective as vane type vortex generators, are now at least as effective.*

It has been found that the performance of a jet flap can be conveniently and accurately predicted, as far as centre of pressure and three-dimensional induced drag effects are concerned, by postulating a mechanical flap with equivalent lift and drag. The angle of the mechanical flap is found to be half that of the jet flap, and for moderate jet angles the chord is a direct function of jet strength.

Another method of establishing a separation bubble is the "free stream line" flap illustrated. The flow separates from the leading edge at *A* and is induced by boundary layer control to reattach to the flap at *B*; along the "free stream line" *AB* the pressure is nearly constant. The blowing quantities needed for a given lift coefficient are considerably less than for a jet flap.

The extension of wings by blowing through a spanwise slot in a tube projecting from the tip has been found to need a tube with a thick high-lift aerofoil section; the most successful had a t/c ratio 50 per cent and a



"Free steam line" flap: the flow is caused to attach to the flap by blowing at its leading edge

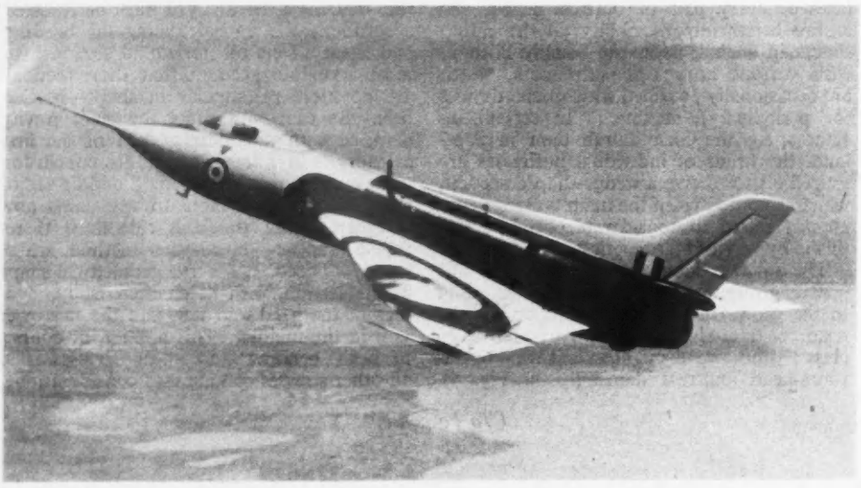
bump in the profile behind a slot tangential to the surface, and attained a C_L of 7·2. An extreme section with a trailing edge angle of 90 deg. has been tunnel tested. This scheme for increasing lift is expected to compare favourably with blown flaps on a fighter aircraft. Work on the other scheme mentioned last year, using a jet sheet inclined downward and outward from the tip of a low aspect ratio wing, has been continued at Sydney University and a report prepared on the characteristics at low speeds. The use of a half-wing of aspect ratio 6 with an "end" plate dividing off a half-wing of aspect ratio 3 was deemed unsatisfactory, and

* See previous report, THE ENGINEER, page 880, June 7, 1957.

a new wing of aspect ratio 3, incorporating flaps, is being built.

To investigate whether shock-free recompression can occur on a wing in fact, as in theory, a model which will theoretically have a shock-free supersonic region with local Mach numbers up to 1·13 in a free stream at M. 0·8 is being manufactured. The design method resulted in the leading as well as the trailing edge being sharp—the theory is valid only for zero incidence—and the surface concave in front of the trailing edge.

Human engineering is now a sub-division of aerodynamics. A study of human operators of a position-controlled system showed that a human behaved as an intermittent or sampling mechanism, thus explaining the 2 c/s periodicity in tracking records. Questionnaires returned by civil and military pilots showed that over one-third had had a more or less critical experience during final approach in the preceding twelve months; this is attributed to the large number of Australian fields where the approach is over water or land devoid of any lights at night. Apparently the low incidence of fog means that approach lighting may not be justifiable. A new ground aid consisting of two bars of lights, one at ground level and one elevated, which will give both roll and glide path guidance, has been developed and accorded favourable criticism. An airborne approach aid has reached the stage where one component, an "aiming sight," is working in the Laboratory and will be installed in an aircraft when manpower is available.



Flow visualisation, by the spread of kerosene over a thin coat of china clay, on the wing of the Avro "707A" shows the presence of a large separation bubble

Structures.—The work on structures has been narrowed down in order to preserve its quality, a number of long-term projects having been abandoned and effort concentrated on three main lines, fatigue, plasticity and creep, and aero-elasticity. Work on fatigue is concentrating on the fatigue characteristics of materials, the work on determining loads in service being regarded as reasonably complete and that on the effect of fabricating the metal being confined to components, the work on complete wings having proved too expensive in manpower. The study of aluminium to 24 S.T. showed that the cold work entailed in abrading processes raised the endurance in fatigue considerably, even when the coarsest grit was used. The enlarged scatter of results showed that chance scratches have a large effect.

The laboratory has observed that work overseas on plasticity has resulted in only the basic formulation of the theory being done thoroughly, and even this work is unsatisfactory in the sense that no one set of hypotheses is consistent with more than a narrow range of experimental observations. (This criticism, it is stated, is not relevant to the technique of limit design.) The A.R.L. work has been on mild steel I-beams strained as cantilevers; it has shown that plasticity is always associated with creep. When a high stress is reached creep first occurs at a fast rate, and then slows down 90 per cent within thirty minutes. It is suggested that the concept of time-independent plasticity may have to be abandoned, except in such fields as limit design, and an attempt is to be made to formulate a mathematical theory of creep which will account for observed plasticity phenomena.

An investigation of large deformations of an elastic ring compressed along a diameter led to a simple formula for the non-linearity of proving rings.

Materials.—A super elastic alloy of copper, aluminium and nickel has been developed which, in single crystal form, will allow elastic deformation up to a strain of 0·07; this is attributed to a martensitic transformation. The fatigue life of this alloy in reverse bending $\pm 0{\cdot}02$ strain is 50,000 cycles compared to 50 cycles for normal metals. A single crystal 9in by $\frac{1}{4}$in by $\frac{3}{8}$in has been made as a calibration bar for resistance strain gauges.

Theoretical studies of the ductile-brittle transition temperature have been advanced far enough to explain the achievement, by annealing at high temperature, of a transition point of —139 deg. Cent. for chromium containing 0·008 per cent nitrogen. The development of chromium base alloys for use in gas turbines is continuing. Higher current efficiencies have been achieved with an electrolytic cell depositing chromium from a chromic acid-fluoride electrolyte than with sulphate electrolyte; the ductile-brittle transition is —87 deg. Cent. for fluoride chromium compared to —60 deg. Cent. for sulphate chromium, due, it is thought, to a silicon impurity derived from fluoride attack on the glass tank. A 10 per cent tungsten alloy has been formed into thermal shock specimens for test by the National Gas Turbine Establishment, while two blades extruded from 10 per cent tungsten alloy were engine tested and showed no signs of thermal shock cracking.

Mechanical Engineering.—For the evaluation of the chromium alloys in engine work, a high temperature turbine is being designed to run in the exhaust of an "Adder" engine. An afterburner for the "Viper" is to be designed to run at a pressure of $\frac{1}{2}$ atmosphere and reheat from 650 deg. to 1400 deg. Cent.; a variable-area nozzle of the central plug design will be used. (The reports published during the year included one on the failure of several "Viper" Mk. 100 engines in "Jindivik" airframes.)

The test rig for the oxygen lance has enabled the "Avon" chamber to be taken up to a simulated 70,000ft at idling, and the combined nozzle and igniter system to be tried in a "Canberra" is on order. A British engine manufacturer is interested in the principle, to the extent of having modified fuel injectors, not only for turbo-prop, but also ram-jet engines.† The combustion of solid fuel has also been investigated, the initial results indicating that, as with liquid fuels, combustion intensities depend upon pressure squared. The brown coal feeding process has been simplified by eliminating the "fluidiser" which added about 10 per cent air by mass to the coal and instead using about 25 per cent air to carry the coal from the coal pump in the "aerated" state.

Attempts are being made to design a model "thrusting wing," a wing whose supersonic characteristics are improved by ram-jets enclosed within it.

The flight research group was active both within and without the Laboratory. The main project has been the testing of the Avro "707" (illustrated), which has included pressure plotting, location of shock waves by shadows, and flow visualisation by discharging smoke from the leading edge.

Operational research was devoted largely to the effectiveness of a missile with command guidance. Two approaches were followed, one a mathematical assessment of probable performance, some of the assumptions being checked by experiment in the field, and the other a "war game" technique introducing human factors. The Laboratory took part in the development of such a weapon, and evolved a high-speed wire dispensing gear for the control link.‡ The use of ground-to-air missiles to defend a large industrial area was also examined by the war game method.

Other assessment work during the year included a study of the probable future staffing problems to be faced by the establishment.

FUSED QUARTZ REFERENCE BOOK.—The Thermal Syndicate, Ltd., Wallsend, Northumberland, has published a reference handbook entitled "About Vitreosil." In the handbook the properties of "Vitreosil," such as resistance to chemical attack, impermeability, resistance to heat, thermal conductivity and electrical characteristics, are briefly stated. Individual sections discuss the use of the material in laboratories, for chemical and industrial plant, domestic applications, including notes upon the working of fused silica. There are a number of appendices; one records the chemical behaviour of "Vitreosil" in contact with a wide range of substances, and another lists the determinations which have been conducted satisfactorily in "Vitreosil," while a third lists electrical, optical, physical and thermal data and particulars of mechanical properties.

† See "Gas Turbines in 1956," page 27, January 4, 1957; the series-compressor "Olympus" has an extremely high flame-out ceiling.

‡ This presumably refers to the "Malkara" anti-tank missile.

Shop for Large Structural Assembly Work

A new erection shop has been built at the works of Ransomes and Rapier, Ltd., for the assembly of large structures for the firm's walking draglines and other equipment. This shop, in addition to making it possible to handle much larger work than hitherto, incorporates a number of structural and equipment features designed to promote economies in maintenance.

FOR some years difficulties have been experienced in the Ipswich works of Ransomes and Rapier, Ltd., in providing accommodation in the existing shops for the erection of the superstructures of large walking draglines, owing to the restrictions imposed by limited clear floor space and working height. This erecting problem was considerably accentuated when about six years ago the firm built the first of the very large "W 1400" walking draglines, and it became necessary to place contracts for the construction of the main superstructure for this and two subsequent machines with other firms. Although this procedure has been satisfactory to a degree, it has had certain drawbacks in the planning of final erection on site of those units made in the works and those by contractors. Further preliminary works erection of main structures has had to be effected without the desirable close liaison within the parent factory where other parts, such as the base, are fabricated and assembled.

In order to provide the desired facilities for works assembly of large superstructures and other parts, the firm has now built a new erection shop which is of sufficient size to accommodate the largest machine structures likely to be required in the foreseeable future. In this shop there can be assembled all the component parts fabricated in the works, and the necessary adjustments made so that final site erection of large main assemblies can be carried out without complications when coupling them together to form the main structure of a machine.

The new shop, a photograph of which we reproduce on this page, has been designed throughout by the firm's own engineers, to suit the particular requirements of its products. The construction of the building was completed in just under a year, the contractors for the steelwork being Cocksedge and Co., Ltd., and those for the building work R. Bennett and Snare, Ltd., both of Ipswich. In its layout, much thought was given not only to the best possible working conditions but also to the need to provide easy access to all parts of the building in the future, for cleaning and the maintenance of services and plant. Some of these provisions have, naturally, added to the basic cost of the building, but the savings in labour and time they will make possible with the passage of time will undoubtedly more than justify the initial outlay.

The new building is a steel-framed structure, providing a clear floor area some 260ft long by 93ft wide, with a height of 50ft below the crane hooks. On one side the building is flanked by a smaller existing shop, to which access has been provided. Its outer side adjoins a narrow road and cleared ground, which will later be available for extensions if required. The sides and ends of the building have an outer cladding of corrugated asbestos sheet with an inner lining of flat asbestos faced insulating board. The side of the building facing the road, and along which future extensions may be made, is faced to a height of some 12ft with a brick wall. This wall has been built with lime mortar so that it can easily be pulled down and its bricks recovered for other work when an extension is built. Large glazed sections in the side walls and roof provide an excellent level of natural lighting in all parts of the building.

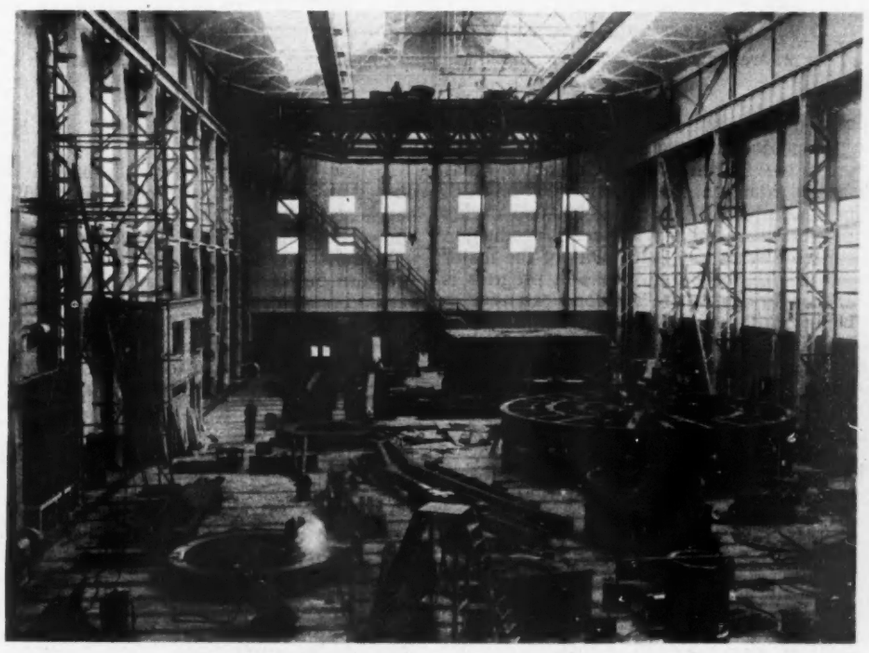
The ground upon which the shop has been erected is mainly of loose sand and silt, and it presented a number of problems in providing adequate foundations for the main stanchions. At the outset it was considered that deep piling would be difficult and costly, so it was decided to design special bases to support the stanchions. Each of these bases consists of a grillage of deep, rolled-steel joists locked together and embodied in a solid block of concrete. The stanchion bases are fixed to the grillage members by high tensile bolts. In anticipation of an extension being built along the road side of the building, the stanchions of the outer wall are of double-sided construction with provision for an outer crane gantry rail. These outer stanchions are supported on extended grillage bases designed to carry the working load of a second set of overhead cranes when an addition is made to the building.

Cast iron levelling and erection rails are let into the surface of the floor across the width and down the full length of the shop. These rails play an important part in enabling the initial precision erection of structures, and when they were installed particular care was taken to ensure accuracy in their level and alignment. It is claimed that the degree of accuracy attained in levelling the rails is such that a maximum overall tolerance of 0·015in has been maintained over the whole of the floor area.

Only one 7in horizontal boring machine is being installed as a fixture on the shop floor, as it is proposed that all machining operations which might be necessary shall be effected with portable machine tools to give a complete degree of flexibility when programming floor occupation. Electric welding is used extensively in assembling components on the large structures, and at a number of points round the walls welding transformer sets have been installed on platforms 15ft above floor level, so that they are well clear of the working area.

The length of the shop is served by two Morris 40-ton overhead travelling cranes, and when necessary these cranes can be used together for the joint lifting of heavy loads. When the main roof structure was being designed it was decided to make provision to facilitate and speed the initial erection of these overhead cranes and also to enable the easy removal and lowering to the floor of any of their component parts for major overhaul or repair purposes in the future. For this purpose a specially strengthened section was built into the main ridge beam of the roof, and it is fitted with pin sockets from which suitable sheaves can be slung. The value of this provision for handling the heavy crane sections was shown during their erection, when all the main bridge parts and machinery for the cranes were hoisted up and assembled together in two or three days, without need for shear legs or other lifting means.

Access to the crane gantry for the crane operators is provided by a stairway at each end of the shop instead of the more usual wall ladders. One stairway is extended to roof truss level and gives access to two walkways which are carried on the cross members and extend the full length of the shop. These walkways, in addition to providing an easy means for inside roof maintenance, will



New shop for assembling large structures at the works of Ransomes and Rapier, Ltd.

facilitate the cleaning and maintenance of the main overhead lighting system in the building.

Doors at each end of the roof walkways give access to a catwalk round the outside of the building at eaves level and two further catwalks along the roof itself at the lower end of the glazed sections. With the free access provided to all parts of the roof by these walkways, maintenance and cleaning work can be readily carried out without the need for erecting expensive staging or scaffolding, either inside or outside the building. An interesting point indicating the forethought which has gone into the building is the use of steel water piping for the hand-rails along the catwalks. These water pipes are connected to a 3in high-pressure water rising main and spaced along them are taps with hose couplings. By coupling short lengths of hose to the hand-rail taps the glazed roof and wall sections can be washed down without any difficulty, at regular intervals, so that the initial standard of cleanliness which has been set is maintained.

The interior of the building is heated by four " Flexaire " oil-fired hot-air circulating units situated along one side wall, whilst adequate ventilation is provided by Colt chain-operated ventilators along the roof. Provision is being made for one of the heating units to supply a curtain of air from an overhead duct across the 20ft square main door of the shop when it is opened in cold weather. A twin-door entrance chamber was considered for heat conservation purposes, but the size of the loads brought in by rail trucks made it inconvenient to allocate such a large space as would have been required.

The actual construction of the new building was only started little more than a year ago and it has already been in use for several weeks. In the illustration there can be seen in course of construction the base of one of the firm's " W.600 " draglines, and when this is completed work will begin on the assembly of the superstructure of the fourth " W.1400 " dragline which is now on order.

Motor Car Factory Extensions

The British Motor Corporation has invested some £22,000,000 *in new factories and equipment since* 1955 *and extension programmes now in hand will involve the expenditure of a further* £18,000,000 *in the next twelve months. As already announced, the corporation sold* 504,712 *vehicles in the year ended July* 31 *last, and the schemes at present being carried out will increase productive capacity by some* 30 *per cent. In the course of a recent visit to factories of the corporation we were shown work in progress and completed on some of the expansion schemes.*

IN addition to extensive works expansion schemes carried out over the past three years the British Motor Corporation has factory extensions and plant installation work in hand which will cost £18,000,000 during the next twelve months to increase production capacity by 30 per cent. One of the major schemes the corporation has in progress is at Longbridge, where a second extension is being made to the existing car assembly building. This new extension will include a storage area of nearly 30,000 square feet which will receive bodies via a bridge from a new paint plant, from the existing paint plant in the Trentham building through an underground tunnel, and also from the roadway at a special loading bay. When in operation the new plant will be capable of dealing with a much wider variety of vehicle models, and to meet this increased production there has been evolved a very flexible system of supplying operatives with the necessary components and materials, such as the correct trims for various bodies. Under this " unit issue " method, as it is known, bodies, as they are received in the storage area, will be sorted out by a punch-card system and placed in the correct sequence for transfer to the trim lines.

Each of the trim lines will consist of two tracks—one carrying the body and the other two trucks, situated in line opposite the body, and these trucks will contain all the trim components for the particular body model.

This truck batching procedure will eliminate the necessity for setting up reservoirs of material at numerous points down the line, which was previously normal procedure. It also diminishes the possibility of wastage caused by damage under the old method, such as trucks running over fabrics and trim components. Two of these production lines, each with its own parallel line of feeder trucks, will be used and with them the introduction of a new model, changes in a model, or variations in demand can be accommodated efficiently.

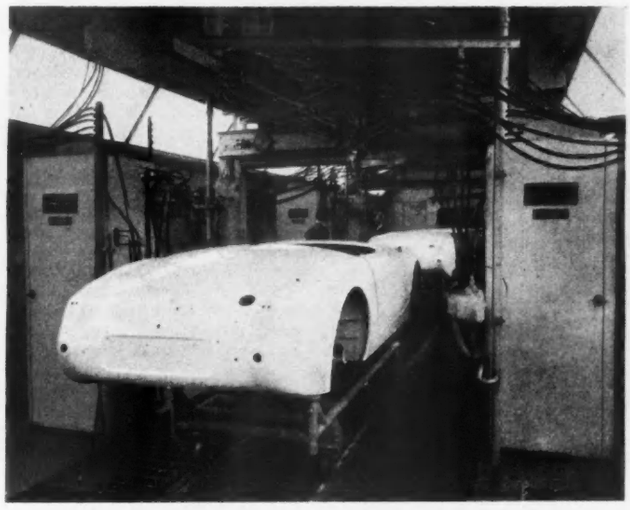
A new painting plant, which has been opened at Cowley, has cost some £3,000,000, and is stated to be one of the most modern and efficient of its kind in the world. When it is in full production in the near future it will turn out rustproofed and finish-painted car bodies at a rate of nearly one a minute.

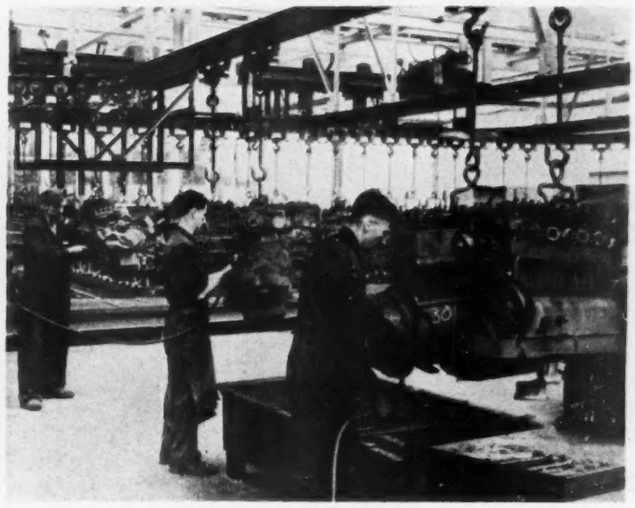
Body shells are delivered to a storage area in one corner of the plant, from where they are drawn according to a schedule and placed on trollies for transport through the lines. These trollies are drawn along the lines by a chain haulage system let into the floor, and they can be quickly fitted with adapter pieces to suit them for the transport of any particular body model. At the final stage of the painting lines when the bodies have been removed, the trollies pass down into an underground tunnel system and returned to the loading station. At present bodies are received ready for painting, but they will shortly undergo the initial rustproofing and anti-corrosion treatment in a new " Rotodip " line. On this line the bodies will be carried through fifty-one stations in a 1 hour 57 minute cycle before transfer to the head of the painting lines (Fig. 1).

Each painting line snakes backwards and forwards and the shells are carried through successive paint spraying, rubbing down, inspection and drying stations. In the paint spraying booths automatic " Schweitzer " spray painting equipment has been installed. One of these equipments can be seen in Fig. 2, showing Austin-Healey "Sprite" body shells in treatment, and in it the spray guns are traversed automatically over the profile of the body shells under the control of light cells, which position the guns and switch them on as a body is carried through. From each of the spray booths the bodies pass up an incline into an adjoining baking oven situated on a mezzanine floor. It takes some forty minutes for a body to pass through an oven and it then moves down an incline to a cooling tunnel at floor level. From the cooling tunnels the bodies pass to rubbing down lines after the undercoating, filling and sealing operations, or on to the finishing lines after the final painting has been completed.

The finish spraying booths are supplied by pipelines with twenty-six paints of different colours, which are used singly or in combinations for duotone painted cars. These paint supply lines terminate in panels at the sides of the booths and the spray gun feed pipes are rapidly and easily coupled to the required colour line by quick-action connections. All of the paints used in finishing are supplied through pipelines from a nearby central mixing and storing house, where a close control is maintained over the paint consistency and standard. Each different colour paint is premixed with the requisite thinners

Fig. 1—General view of new painting plant. The " Minor 1000 " bodies in the centre foreground have received two coats of surfacer and are passing through the rubbing down stage preparatory to receiving the sealer coat. In the middle distance can be seen the baking ovens on the mezzanine floor





Figs. 2 and 3—(Left) Finishing paint spray booth with automatic spray guns actuated by interruption of light rays. Each gun can spray any one of twenty-six colours. (Right) Preliminary stripping section of engine re-building plant

for spraying in a 100-gallon mixer and transferred to a second mixer, where it is agitated continuously ready for delivering to the paint line as required.

A continuous downwards flow of cleaned air is maintained in all of the paint spraying booths and the water used to wash the paint-contaminated air flows down into large sludge tanks in the basement below the booths. Each of these tanks is of 50,000 gallons capacity and the water from above flows down into one side. As the water is drawn out of the other side of a tank for recirculation, the paint scum floats across the width to come to rest against a partially submerged panel suspended from a rail girder. Along this rail girder and an adjacent rail girder there runs an electrically-driven carriage, which periodically traverses the length of the tank and skims the paint scum off into a hopper at one end. This hopper can be raised as required on a lifting gear and taken on a special wheeled truck to a dump for emptying.

Unit Replacement Plant

The replacement of worn engines and gearboxes now forms an important part of the B.M.C. organisation and under an extensive modernisation scheme the whole of the rebuilding of engines and gearboxes for all Nuffield and Austin vehicles has been centred in two large workshops in Durbar Avenue, Foleshill, Coventry. The scheme provides for the replacement of worn engines and gearboxes by units which have been completely rebuilt from new or reworked parts which have been inspected, tested, and assembled with the same degree of care that is devoted to the production of engines and gearboxes for current models. At present some 1500 engine units are rebuilt a week, and rapid progress is being made to achieve the full potential of 4000 units a week. It is of interest to note that engine models twenty years old can still be rebuilt in the plant, part of the dismantling line of which can be seen in Fig. 3; notice the carriage of engines by the rocker shafts.

All of the stripping down and repair work is carried out in one of the two shops. The incoming engines are delivered into a storage area at one end and after inspection to ensure that no gross damage has been suffered from impact or neglect the engines are marshalled in storage racks in groups of the same type. From the stores the engines are issued to the stripping-down lines where in a sub-section the sumps, rocker covers, side-plates and core plugs are removed. The sumps and usable covers are cleaned, inspected, reformed, painted, and sent to the stores. After draining away any remaining oil each engine then passes through a machine in which it is sprayed with jets of hot cleaning solution to leave it superficially clean and ready for dismantling. As each component is removed it is placed in an individual container, some for recovery and others, such as pistons, valves and bearings, being automatically discarded for scrap as no longer recoverable. Recoverable parts are then passed through a number of cleaning solutions and solvents to remove oil, sludge, rust, and carbon prior to inspection before being sent on down the line to the rework section. In this section such machining operations as the reboring of cylinder blocks, regrinding of crankshafts, &c., are carried out to standards of finish precisely the same as for new engines in current production. Cylinder reboring and crankshaft regrinding for recovery are each carried out to one of three standard sizes, so that on re-assembly engines can be fitted together, using three complementary sizes of pistons and bearing shells.

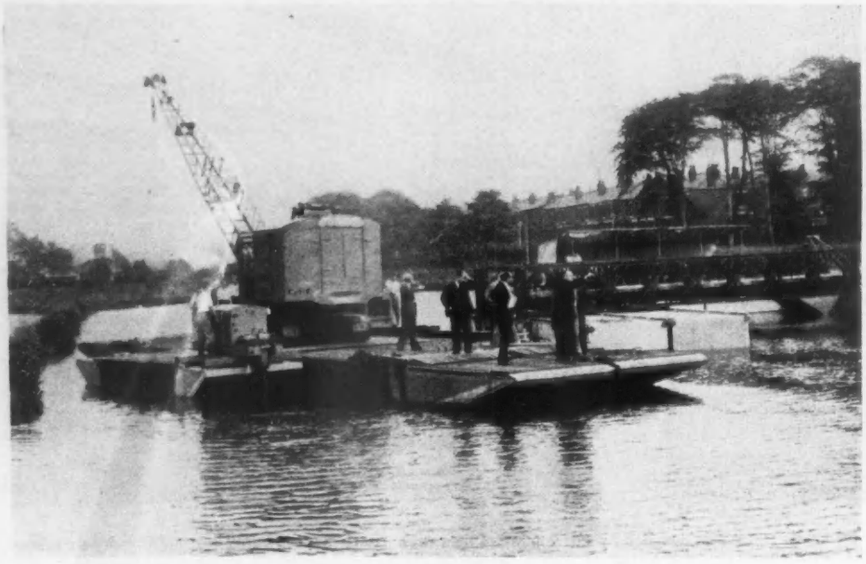
All the recovered components are marshalled in a large stores at one end of the the second main building. In this stores the complementary new and recovered parts for each engine are marshalled into complete sets and dispatched via a washing section to the five main assembly lines. The engines are at the end of the line coupled up to motor drives and given a " cold " run with a flush of oil before the sumps are fitted. After the sumps have been fitted the engines undergo a performance running test and 5 per cent have a dynamometer running test to ensure that they attain full power requirements. In addition to these tests a number of finished engines of each type are completely stripped by the inspection department and independently by the engineering research department. The displayed parts, with every fault that can be found carefully noted, are inspected by the management staff concerned.

The treatment of gearboxes returned for recovery is much the same as for the engines, except that gears can very rarely be used again. Consequently, replacement gearboxes contain a higher proportion of new parts. Finished replacement units are stored by types in four-tier racks ready for dispatch through loading and unloading bays adjacent to the main works entrance.

Spares and Service

To combine and co-ordinate the activities of the Austin and Nuffield service departments an organisation known as B.M.C. Service, Ltd., was set up in 1956 and some large new stores buildings have been laid down recently. The warehouses at Cowley now cover an area of some 850,000 square feet and house approximately £8,000,000 worth of parts. It will be appreciated that the multiplicity of models produced by B.M.C. creates many service problems when it is considered that parts for vehicles which are not being currently manufactured must still be available to owners all over the world. The policy adopted to cover this is to make a " terminal buy " of eight times the previous year's usage of spare parts for a model as soon as its production ceases. This has introduced a problem of storage and the corporation has adopted the policy of using common parts and components so that they are, to an increasing extent, interchangeable between the various models. This will in due course reduce the number of individual parts which are required to service the whole range of vehicle models, which is at present some 20,000 fast-moving and 80,000 comparatively slow-moving parts.

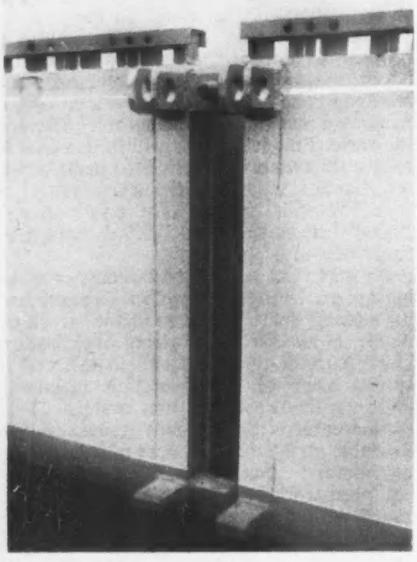
An important part in the business of making and marketing motor vehicles, in addition to making spare parts available at short notice, is an efficient servicing organisation in all parts of the world and to this end a special technical service section maintains liaison with distributors and dealers. This section ensures that correctly trained staff is available at the establishment of a dealer or distributor ; that he has an adequately equipped workshop; and that he is kept in touch with development by comprehensive technical literature. Specialists in the central service department give advice on the best layout and equipment for their workshops to dealers, and a number of training courses are attended by personnel from all over the world for tuition in maintenance, repair and servicing, as well as instruction on new developments as they are introduced on the vehicles made by the corporation. In addition, a travelling staff of factory-trained service engineers visit the works of dealers and distributors to keep them up to date with developments and instruct their mechanics.



Floating Construction Units

IT is some time since the "Uniflote" was evolved by Thos. Storey (Engineers), Ltd., to be capable of the widest application in the requirements of civil engineering and to provide basic flotation units able to integrate with existing equipment. The design provides for the construction of floating platforms of various shapes and loading capacities to act as landing stages, jetties, wharves and piers, while the detail design ensures that the units are capable of touch assembly by day or night.

The Storey "Uniflote" has dimensions in plan of 17ft 4in long by 8ft wide, and is built in three depths, namely, 4ft, 6ft and 8ft; it is basically a rectangular tank built of ordinary angle bar and steel plate. All-welded construction has been adopted and the unit is subdivided into three compartments by two watertight divisions, access to each compartment being by means of a portable watertight plate in the deck. The unit is divided into nine frame spaces so that in each compartment there are two welded angle bar frames, while along the centre line is a longitudinal frame. Plate panels form the skin of the float and are lap welded to the bar with intermittent welding connections on the inside. Constructional work is carried out in a jig to maintain dimensional accuracy and then patent couplers are welded on at points along the sides and ends, at top and bottom, and positioned to close limits. These couplers are designed to allow the "Uniflotes" to be connected together, either side by side, end to end, or side to end. The upper units are designed to take a connecting pin, while the lower couplers are in the form of hooked lugs, so slight adjustments of trim ensure that they lock automatically, thus obviating any under-water work. Our illustration shows the welded plate panels, the upper and lower couplers and the special gunwale bar. The gunwale bars provide a means of attaching various designs of superstructure or take bridging connections. The underside of the pontoon is protected by steel runners.



"Uniflote" upper and lower coupling arrangements

Three plate thicknesses are employed for the panels, namely, $\frac{3}{16}$in, $\frac{1}{4}$in and $\frac{5}{16}$in, according to service requirements, and a "Uniflote" having $\frac{3}{16}$in plating weighs just over 3 tons and floats at a draught of 9·33in. Thus a "Triflote" has a tons per inch immersion of 1 ton, or a "Uniflote" will support a load of 10 tons with 9in of freeboard. The design strength is such that four units can be connected end to end to form a rigid raft 70ft in length, and rafts can be assembled up to 70ft square. For any length greater than 70ft, tidal connectors are available and provide the flexibility required due to the variation of buoyancy, and consequently bending moment, caused by waves or broken water. "Uniflotes" may be ballasted as required, and in each compartment is a standpipe and a hose connection so that the ballast water can be ejected by compressed air.

In addition to the rectangular pontoons there are special units, weighing about 1 ton, to act as bow and stern units and also as cutwaters, while other units are designed as adjustable ramps, the ramp brow being capable of being raised from water level through a distance of 5ft by means of a simple lever and ratchet equipment operating a connecting chain. When forming a raft provision is made for the fitting of "Harbourmaster" propulsion units so that the raft can operate as a ferry and be free ranging.

We recently attended at Stockport a demonstration of "Uniflotes" used for supporting a bridge and also assembled to form a ferry or floating landing stage. At the demonstration Bailey bridging was shown as a static exhibit, carried on "Uniflotes" used both as a grounded crib and as floating pontoons, and the technique of coupling the "Uniflotes" in various formations was shown. The technique is simple, the joining together being effected by slightly tilting the pontoons, then drawing them together and pinning at deck level before allowing them to float on even keel so that the hooked lugs at the base interlock. The simplicity of the joining drill was underlined by repeating the operation with the crew blindfolded, thus showing that the job can be done equally well by night as well as by day.

A "Uniflote" ferry was on view and this consisted of two sets of three "Uniflotes" joined side to side and each having articulating ramps at the ends. On each side of the raft at midlength was a "Uniflote" complete with bow and stern units and a "Harbourmaster" power unit. The manœuvrability of the powered raft was ably demonstrated, also the raising and lowering of the ramps, while its value as a floating platform was shown by a number of landings and take-offs by a helicopter. Later a mobile tracked crane crossed the Bailey bridge and then proceeded down ramp sections on to the "Uniflote" raft, which was secured to the bridge "Uniflotes" by articulating connecting links. The raft moved under its own power to the bank and landed the crane. The raft, with the tracked crane on board, can be seen in our illustration, with part of the Bailey bridge and supporting "Uniflotes" in the background. The manœuvre was repeated with a six-wheel chassis mounted crane.

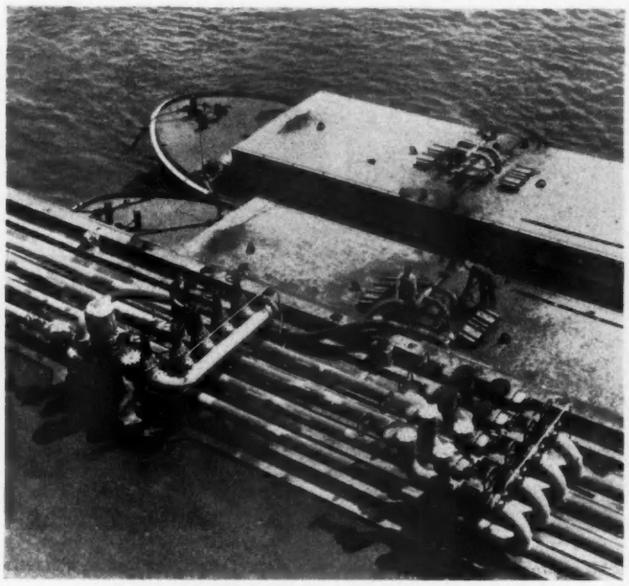
It is understood that the testing and proof loading of a group of "Uniflotes" has been carried out successfully at the Ministry of Supply Experimental Establishment at Christchurch, and that sea trials will take place to prove the ability of these rafts to transport indivisible loads up to 200 tons.

Fuel Oil Terminal at Poplar

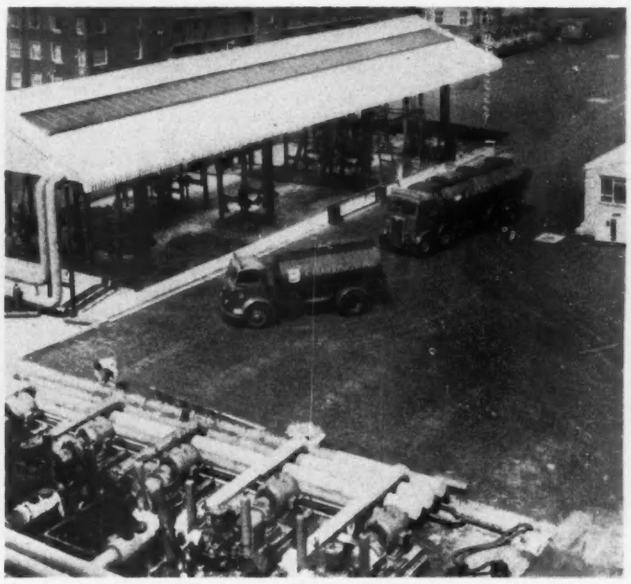
IN 1858 Charringtons opened a coal wharf at Ratcliffe and 100 years later at Poplar, 2 miles away, the company, now known as Charrington Gardner Locket (London), Ltd., has constructed a fuel oil terminal which was opened on Monday, September 15 by Mr. J. C. Gridley, the chairman of Mobil Oil Company, Ltd. The new terminal is the fourth of such establishments which the company has built since it entered into an agreement to market Mobil oils five years ago, the other terminals being located at Norwich, Cambridge and Bedworth. The site is that of the old dock and railway sidings at Poplar, owned by British Railways, which were in operation until the war during which bombs breached the dock wall and destroyed the dock gates.

Rapid expansion in the consumption of various grades of fuel oils in recent years and the prospect of the continuance of this trend pointed to the need for improved facilities giving higher speed and greater certainty in delivery and effecting economies in handling. Mr. C. P. Humphris, the company's chief engineer, has been largely responsible for the development of the terminal which occupies an area of 10 acres of which the present plant makes use of four, leaving 6 acres for future development. Plans have been drawn up and incorporate a degree of flexibility to allow for their adaptation to meet future needs.

Four grades of oil are handled and the terminal provides storage for a total of 18,500 tons, over 4,000,000 gallons, in four tanks, namely, three of 4000 tons capacity and one of 6500 tons capacity. Oil is transported by barges, generally built at the company's yard at Dartford, from Coryton refinery, transferred to storage and thence by means of automatic pumping equipment to road tankers for delivery. This arrangement eliminates the possibilities of the dislocation of supplies due to road traffic conditions and ensures prompt delivery of fuel to central London areas, both north and south of the Thames. About 400,000 gallons can be loaded per day. Waterborne traffic is largely free from



Part of a quay showing pipelines and barges being off-loaded



Road tanker loading bay and part of transfer pump apron

restrictions and since the terminal is within a few miles of the City of London final distribution is greatly facilitated. Furthermore, deliveries can be effected at an early hour and the quicker turn round of vehicles makes for increased availability and greater operating efficiency.

There is a quay 700ft long constructed by John Shelbourne and Co., Ltd., which will accommodate about nine 200-ton barges and mounted on the quay are two 120 tons per hour "Imo" pumps for handling the three grades of black oil products and one 54 tons per hour "Imo" pump for dealing with the gas oil. The pumps off-load from the barges by a 6in armoured hose and deliver to the storage tanks through 10in pipelines which are fitted with Crane gate and check valves and special manifold connections to serve self-propelled tankers when these are in service. Part of the quay and pipeline systems together with barges being off loaded can be seen in our illustration. Three of the storage tanks, all of which were built by W. Neill and Sons, Ltd., are lagged and two of them are equipped with heating coils.

For the distribution of the fuel there is a fleet of road tankers, of up to 3600 gallons capacity, for the loading of which there are eight bays each having three loading arms capable of delivering 300 gallons of oil per minute. We illustrate road tankers approaching the loading bays and some of the transfer pumps on the pump apron. Ticket printing meters at each arm record the quantity of fuel loaded and the accuracy of the meters is constantly checked by certified proving tanks of 150 gallons capacity and maintained at a tolerance of one-tenth of 1 per cent. Transfer of oil from storage to the loading bays is automatically controlled and on the pump apron are six 600-gallons-per-minute Plenty positive displacement black oil pumps driven at 173 r.p.m. by 75 h.p. electric motors and two 500-gallons-per-minute centrifugal gas oil pumps powered by 30 h.p. motors and manufactured by Lee Howl, Ltd. There is also a 1 h.p. pressure control or booster pump. Automatic switchgear increases or decreases the number of pumps in action according to the number of road tankers loading, the maximum delivery rate being 1200 gallons per minute for each grade.

Hot water for heating the tanks and other purposes is supplied by a "La Mont" boiler, rated at 6,500,000 B.Th.U. per hour, at a temperature of 250 deg. Fah. and 43 lb to 48 lb per square inch. Fuel Firing, Ltd., supplied the burner unit which has a 10 to 1 turn down ratio and consumes 40 gallons down to 4 gallons per hour of fuel of 1500 seconds Redwood viscosity. There are two English Electric water circulating pumps and one "Imo" oil circulating pump and a pressurisation unit provided by Matthew Hall and Co., Ltd. In the compressor house are two Broom and Wade compressors driven by 136 h.p. motors and capable of delivering 600 cubic feet of free air per minute at 100 lb per square inch. The air is stored in two receivers and its main purpose is to put out a tank fire by the air agitation method, special piping being fitted in the tanks for that purpose. Also in the building is a Spanner "Swirlyflo" boiler rated at 2000 lb per hour for supplying steam at 50 lb per square inch to the barges for oil heating purposes. For the maintenance of the road vehicles there is a washdown building equipped with a "Washmobile" unit and a Laycock "Merlin" vehicle washer. The office block which is in Telex communication with the company's head office and Coryton refinery, incorporates a mess room, washing facilities, a kitchen and locker room for the drivers.

The architects for the terminal were A. F. Hare and Partners and the main contractor was Leonard Fairclough, Ltd., while the heating engineer was Matthew Hall and Co., Ltd.

Test Station for Small Circuit Breakers

A SHORT-CIRCUIT test station designed for testing contactors and small circuit breakers at currents up to 10,000A at 440V, three-phase, has been established at the Lincoln works of J. A. Crabtree and Co., Ltd., Walsall, Staffs. This test station is the newest addition to the company's electrical laboratory which is equipped with a.c. and d.c. supplies and instruments for testing Crabtree products at various ambient temperatures and humidities and under special conditions complying with American, Commonwealth and European specifications.

The new test station, like the Crabtree laboratories, provides means for proving existing products and for improving their design and performance and it exercises a strong influence on the design of new products. This influence is especially marked in the development of a product such as the E-60, double-pole, earth-leakage circuit breaker, which belongs to a class of gear that is attracting increasing attention in this country as competitor of the rewirable fuse.

Two views of the short-circuit test station are reproduced overleaf. That on the left shows an operator at the control desk which faces the test cell and is separated from it by a plate glass screen. Both a.c. and d.c. supplies are available for application to apparatus under test in the cell. Although the equipments to be tested are of limited size and capacity the short-circuit load, up to 10,000A, would not be acceptable to a supply authority. Independent supplies are therefore provided locally by the company.

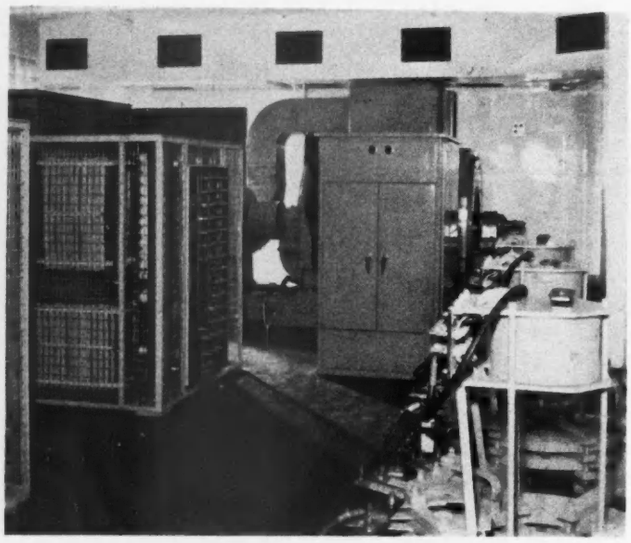
Illustrated on the right is the a.c. test source, a three-phase, 800kVA, four-wire, star-connected alternator with a salient-pole field and a designed reactance to give short-circuit currents up to 10,000A at 440V. A 100 h.p., 1500 r.p.m., squirrel-cage motor drives the alternator and is controlled by an auto-transformer starter with Korndorffer connections. A separate exciter is direct coupled to the motor and alternator, the three machines in tandem being supplied by Mather & Platt, Ltd., and mounted on a common bedplate. The alternator terminals are connected to a solenoid-operated oil circuit breaker, which has a normal continuous rating of 1000A and a rupturing capacity well in excess of the maximum short-circuit current of the alternator. This circuit breaker serves as a master switch, providing back-up protection in the event of failure of the test apparatus to clear the simulated fault. Underfloor busbars connect the master switch with the terminal board in the test cell; air core reactors and resistor banks are connected in each of the three phases with tappings to allow the prospective fault current and power factor to be controlled down to 100A.

The power factor obtainable is about 0·6 at the maximum short-circuit current of 10,000A, 1·0 at 8000A, and 0·1 at currents throughout the working range. Removable links are connected in each phase and neutral between the resistance/reactor banks and the master circuit breaker, so that transformers can be connected if higher test voltages are required.

The machine room has pressure ventilation, requiring 6000 cubic feet per minute, the incoming air being filtered to exclude dust. The cooling requirement of the alternator is 4000 cubic feet per minute and the warm air can be discharged to atmosphere or used to heat the laboratory.

Short circuits are applied to the apparatus under test by an air-break "make" switch which is spring actuated and is provided with an electronically-operated "point-on-wave" control.

Remote operation of the whole station is effected from a control desk in the test bay facing the test cell, safety interlocks and visible and



(Left) Apparatus under test mounted on a fibre board in a test cell facing the operator at his control desk. (Right) Machine room of short circuit test station, with resistor banks on the left and reactors on the right. Part of the motor alternator set can be seen in the background beyond the apparatus cubicle

audible alarm signals being incorporated in the installation. The operations carried out from the control desk include starting up of the ventilating system and then of the motor-alternator set ; closing of the master switch ; setting up of the initiation programme for operation of the make switch either manually or with " point-on-wave " control ; and resetting of the " make " switch, the spring of which is charged by a small motor. Oscillograms taken during a test can be processed in a small dark-room between the test cell and the machine room.

Supplies for direct-current tests can be obtained from a battery room containing two batteries of secondary cells, each of 250V, 500Ah capacity, which are capable, jointly, of delivering short-circuit currents of 5000A at 250V.

Alongside the control desk in the test bay there is room for about thirty observers to view a test and there is a conference table at which the apparatus can be examined and discussed before and after test.

During a tour of the testing station on a recent visit to the Lincoln works we saw a demonstration comparing the behaviour of a 230V, 30A rewirable fuse and a 30A Crabtree miniature circuit breaker. The fuse and the circuit breaker, in turn, were subjected to a short circuit limited to 2000A at about 0·75 p.f., 250V. Both tests were manually controlled, with " counting down " procedure to the instant of short-circuit application, to allow close observation of the test. Whereas the rewirable fuse holder was shattered by the short circuit, the circuit breaker cleared the fault without any sign of distress. We were told that the circuit breaker would, if called upon, withstand fifty operations at 1000A.

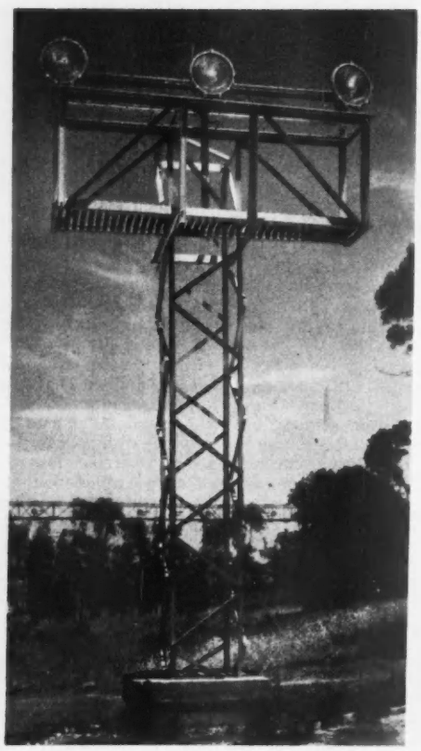
All-Aluminium Lighting Towers at Port Elizabeth Airport

BY OUR SOUTH AFRICAN CORRESPONDENT

THE recently completed lighting towers and poles at Driftsands Airport, Port Elizabeth, present an interesting and unusual departure from normal structural practice in South Africa. Aluminium alloy has been used throughout for the main gantries, the block towers and the lighting poles, all of which were designed by the consulting engineers, McLaren, Davenport and Partners. The main contractor for the entire project was The British General Electric Company (Pty.), Ltd.

Our illustrations show one of the gantry structures and a lighting tower at the airport. The whole approach lighting system consists of three gantry structures, two block towers and twenty lighting towers. The largest of the three gantries in the approach lighting system is 207ft long and 32ft high and constructed from 51 SWP angle sections and M57S plate. The decision to use aluminium alloy for the structures was based mainly on the exceptional corrosion resistance of this light alloy, a property that will reduce to a negligible proportion the amount of maintenance work to be carried out in the future. This is of extreme importance in a coastal climate which normally makes yearly re-painting an expensive item.

Others factors influencing the decision were the lightness and strength of the aluminium alloy and the ease of transport and erection of sections weighing only a third as much as steel. ACOSA 51 SWP aluminium alloy was used for the structural members and M57S alloy in the form of ¼in thick sheet for the gussets. The sections used in the construction of the towers were bulbed angles, standard angles and flat bar, and all components of the structures were riveted with aluminium alloy rivets. The horizontal latticed gantry frames, together with all poles and towers, were completely fabricated on the ground, and after erection of the towers the long gantry frames were lifted into position by using two poles. Once in position on the towers they were site-riveted together. Erection was carried out by the sub-contractor, Power Steel Construction Company (Pty.), Ltd., and all aluminium extruded sections and plate supplied by the Aluminium Company of South Africa (Pty.), Ltd.



Lighting tower of aluminium alloy at Driftsands Airport, Port Elizabeth

Lighting gantry structure of aluminium alloy at Driftsands Airport, Port Elizabeth

SHORTER REPORTS

Stockport Firm's 125th Anniversary

THE Stockport firm of Robert Harlow and Son, Ltd., has been celebrating its 125th anniversary. It was founded by Robert Harlow, a native of Ashbourne, Derbyshire, in 1833, who went to Stockport to set up in business as a manufacturer of cocks and valves and various other brass fittings. Robert Harlow was then twenty-two and had recently completed an apprenticeship with a " grocer and druggist " in Walsall. He was, however, a member of a Derbyshire family of brassfounders and clockmakers, a factor which may quite likely have influenced his decision to forsake the trade in which he served a five-year apprenticeship ! A few years after its establishment, Robert Harlow moved his business to larger premises in Heaton Lane, Stockport. His works remained there for seventeen years, during which time he obviously increased his activities, for although he retained the description of brassfounder, he added other titles, including gas engineer, iron founder and " fitter-up of baths and hot water apparatus." During these years also Robert Harlow, like his forebears, manufactured some clock parts and made at least one complete clock which was installed at the Stockport infirmary in 1842. The growth of the business made another move necessary in 1855. This was to premises in Wellington Road North, Stockport, where the firm, now a quarter through its second century, continues as a family concern with some of the direct descendants of the founder guiding its affairs.

To commemorate the 125th anniversary, an interesting booklet has been prepared by Mrs. Irma S. Harlow. It not only puts on record the progressive development of the firm, but is also in many respects a history of the Harlow family. Robert Harlow, the founder of the firm, was like many another of his day obviously an interesting personality, and an able craftsman. The booklet describes, for example, how in 1874 he built himself a new house in which were incorporated a number of heating and plumbing ideas that, at the time, were looked upon with considerable reserve. Robert's house was heated throughout by hot air circulating up through grids in the floor, and, as well as a bathroom, there were wash basins in the bedrooms—a step which was considered by many of that day to be injurious to the health of the occupants !

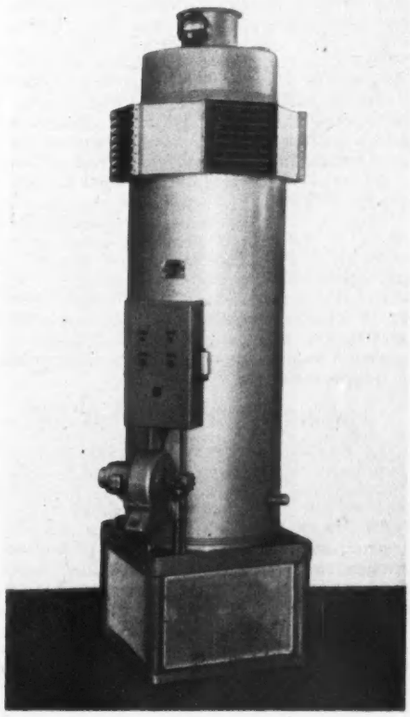
Nasmyth Anniversary Exhibition

To commemorate the 150th anniversary of the birth of James Nasmyth, an exhibition illustrating many aspects of his life and work was opened recently at the Eccles Public Library, Manchester. It appropriately recalls that Nasmyth, who established the Bridgewater Foundry at Patricroft in 1836, was largely responsible for the early industrial development of the Eccles area. The Eccles library has a comprehensive collection of Nasmyth's business and other records. It consists of such documents as articles of agreement, account and letter books, drawings and catalogues, miscellaneous business correspondence of Nasmyth, Gaskell and Co., and patent specifications and other matters relating to Nasmyth's various inventions.

The collection includes several of Nasmyth's own drawings and paintings which emphasise his ability as an artist as well as an engineer. It will be remembered that astronomy was also one of his interests ; this has a place in the exhibition. The most interesting items in the exhibition are naturally the contemporary ones. Alongside them there is a considerable collection of the material about Nasmyth which has appeared in a big variety of publications. Among the latter, we are happy to note that there are included a number of articles on Nasmyth's life and work which have been published over the years in the columns of THE ENGINEER. The exhibition continues until October 3.

Industrial Space Heater

WE illustrate below an oil-fired space heater which is now being made by John Thompson Beacon Windows, Ltd., Wolverhampton. It is based on the design of de Jong, a Dutch firm, and is suitable for factories warehouses and other industrial premises. The principle employed is that of direct contact of cold air forced over heated metal surfaces. Air is drawn in at the base of the heater by a fan (driven by a 2 h.p. motor) and, after passing over the heating surfaces of the combustion chamber, is forced to circulate among a spiral bundle of waste heat tubes before being discharged. Using grades of fuel oil up to a viscosity of 40 seconds Redwood



The output of this heater is stated to be 595,000 B.Th.U. per hour. The unit requires only 9 square feet of floor space

No. 1, the output of the heater is claimed to be 595,000 B.Th.U. per hour. The warm air displacement is 32,000 cubic feet an hour and from louvred outlets warm air is exuded at a velocity of 15ft per second. The difference in temperature between the air in the suction openings and the warm air at the outlets is said to be 122 deg. Fah.

The high thermal efficiency of the heater, 87 per cent, according to the maker, is achieved by employing a spiral tube bundle through which the combustion gases pass from the combustion chamber to the flue. This provides a large heating surface and produces turbulence in the air passing over the tube bundle, thus giving a high degree of heat transfer. To assist the full utilisation of the available heat a baffle is fitted half-way along the tube bundle, and adjustable louvres fitted to each warm air outlet enable the direction of air flow to be varied

The oil burner is equipped with an electronic flame failure protection device ; in the event of flame failure, the burner is immediately shut down and cannot be restarted until the locking switch is reset. Moreover, should the fan fail to come into operation at any time, the burner shuts down automatically. The time relays and thermostats, together with the motor switch, are mounted in a closed case on the shell of the heater.

New Data Processing System

A NEW fully " transistorised " data processing system, known as the " IBM7070," has been introduced by I.B.M. United Kingdom, Ltd., 101, Wigmore Street, London, W.1. It is designed for commercial or scientific use. The time required for an average addition is stated to be less than 0·0001 second, the data input and output systems being of commensurate speed. The magnetic core storage holds 50,000 or 100,000 digits with an access time of 6 microseconds to each word of ten digits. As many as four disc storage units, each with a capacity of 6,000,000 digits, can also be used. Overlapping machine operations save computer time, a system which is made possible because the input and output channels are completely " buffered " to allow for simultaneous computing, reading and writing.

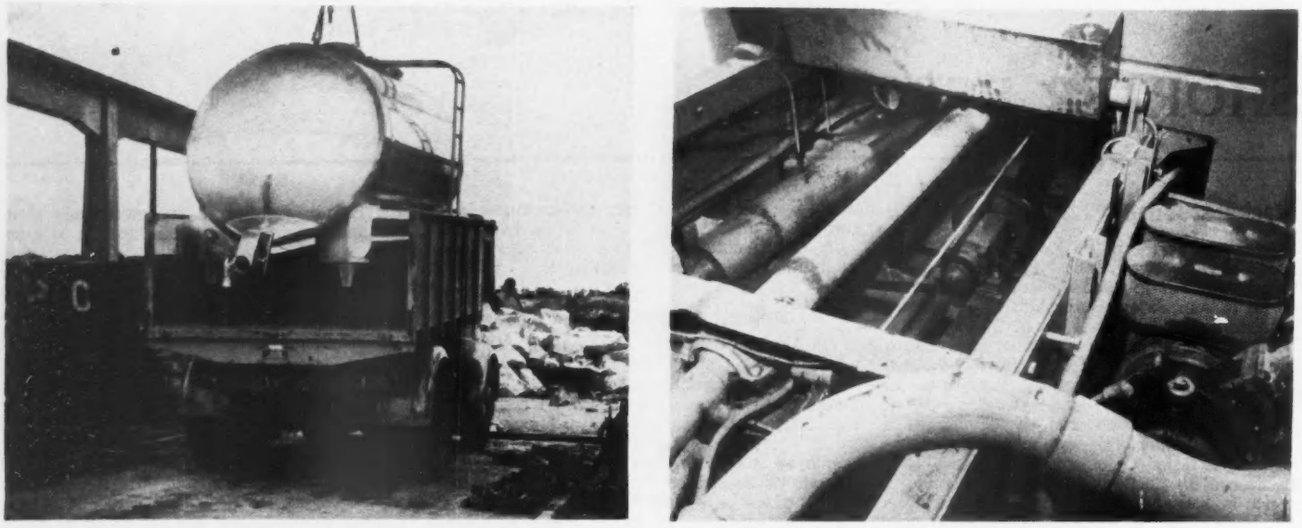
The main particulars of the machine are tabulated herewith :

Input :	
Punched cards	400 cards per minute per reader
Number of card readers	Up to three
Output :	
Punched cards	250 cards per minute } Up to 3 in any
Line printer	150 lines per minute } combination
Console typewriter	One
Inquiry typewriter	up to 10
Storage :	
Magnetic cores	50,000 or 100,000 digits
Disc storage	Up to 4 units, each of 6,000,000 digits
Magnetic tapes	Up to 12 tape units
Speed :	
Storage access time	6 microseconds
Addition/subtraction :	
10 + 10 digits	72 microseconds
Multiplication :	
Average 10 × 10 digits	1,1e0 microseconds
Division :	
Average 10 ÷ 10	3,756 microseconds
Tape reading/writing :	
One	15,000 characters per second
Two	Approximately 62,500 characters per second
Operation :	
Automatic operations	Over 100 basic operations expanded by use of control part of instruction
Scale	Binary-coded decimal
Point	Fixed or floating
Word length	10 digits (or 5 alpha characters), though arithmetic and logical operations may be freely performed on any part of a word as specified in an instruction
Instructions	10 digits per instruction
Address	One address
Mode :	
Data transmission	Parallel transmission of 10-digit word
Arithmetic	Parallel by bit, serial by digit
Index words	Ninety-nine
Size of machine	Floor area 700 square feet

Using two channels the machine can, whilst computing, read or write two tapes simultaneously at a combined speed of 125,000 characters a second. All reading, writing, internal data transfers and arithmetic operations are internally checked, and magnetic tape is automatically checked as it is read and written.

A comprehensive library of programmes offered with the system substantially reduces programme costs. A typical programme is the auto-coder, which is fed into the computer from punched cards, taking English or algebraic notations and translating them into machine language. For scientific work, " Fortran "—the programming system which allows mathematical equations to be entered directly—is used. Location of the decimal point is automatic. The " IBM 7070 " data processing system is designed on the " building block " principle, which allows a user, starting with a high-speed punched card input and output, to increase the system to include magnetic tape and disc storage as his needs expand.

The combination of the high-speed tapes and processing and the disc file permits the " IBM 7070 " to be used for a variety of



(Left) This Commer tipping truck uses a Roots blower to supply scavenge air and a Ricardo supercharger to discharge the cargo. (Right) The tipping mechanism is hydraulic : the pump is chain-driven from the back of the auxiliary drive. Notice the complete enclosure of the Thames transmission

business and research problems. The manufacturer suggests that in commerce, it is particularly adaptable to any application which requires the maintenance of a large volume of records, whether the daily movement within these records is small or large. In scientific research, calculations requiring frequent reference to tables, and the mathematical technique known as the Monte Carlo method, in particular, are simplified by the " 7070's " computing speed and immediate access storage.

Convertible Bulk Carrier

WHEN a bulk load of powdered material is to be discharged by air blowing, as into a silo, the material must be fed to the air jet either by an air slide (a long inclined aeration pad) or by tilting the container steeply enough for the powder to settle under gravity. The latter method, particularly if the tipping mechanism is not located under the container, can yield a lower centre of gravity and overall height, and it also, clearly, has the advantage that the container can be tilted more steeply to deal with difficult materials or adverse site inclinations. Also, the tipping container system has much in common with the conventional tipping truck or dumper, and this fact has been exploited by the Ketton Portland Cement Company, Ltd., in specifying containers which can rapidly be placed in and removed from a normal tipper body. This means that when the vehicle is not required for blown-discharge deliveries it can be used for gravity-discharge bulk carriage or other freight work ; special vehicles must be set aside for the containers, however, since the air requirement is too large to be supplied from the air pressure system or by bleed from the induction of a supercharged engine. For these new blown-discharge vehicles the operator has selected the Wellworthy fourteen-cylinder, double-acting compressor (see page 156, August 3, 1956), which is commonly used on such applications, particularly where rather large pressure ratios are involved in delivering to heights of, say, 60ft. The compressor, in this application, is mounted outside the chassis frame and belt driven from the power take-off ; a pair of Vokes filters protect the intakes. The charge air is carried by a flexible pipe to the tipping container, where part of it is used to energise the transporting jets and a portion is fed to a nozzle plate near the jet to " fluidise " the input to the ejector and to keep the container full of air. A gauge shows the nozzle box pressure, and a lessening of this reading indicates that the container needs to be tipped to bring more material to the back or, of course, that discharge is complete. The blown discharge of 8 tons of cement takes roughly twenty minutes to fill a silo 60ft above the vehicle.

The containers have been fabricated by Bonallack and Sons, Ltd., Basildon, Essex, in light alloy ; mild steel vessels, which weigh 8 cwt instead of 5½ cwt, but are less costly, are available for customers utilising them less intensively. Our illustration shows that the container has four large feet fitted with pegs that enter female pyramids in the floor of the tipping body ; " Pip " pins pass through the wall of the recess into the peg to prevent the container lifting due to road irregularities or being tipped too far when full. There is included stowage for the hoses, and the tank has two manholes in the top for filling. The truck body is a conventional tipper with a " Dekaloy floor," the ports in which are closed by steel hatches when the container is removed.

When a single-purpose, blown-discharge vehicle is required, a Bonallack container is essentially similar, and a subframe is required to distribute the tipping loads over the tank. Our second illustration shows such a vehicle ; this is an " ET7 " Thames, the total enclosure of the transmission having obvious advantages for operation in an environment laden with cement or similar dusts.

Mobile Oil Drilling Platform

ON Thursday afternoon, September 11, more than ninety members and guests of the Southern Association of the Institution of Civil Engineers accepted the invitation of Mr. J. H. Jellett, O.B.E., M.I.C.E., the Docks Engineer of Southampton, and Steel Structures, Ltd., of Western Avenue New Dock, Southampton, to inspect the first mobile oil drilling platform to be constructed in the United Kingdom. It is being built by Steel Structures, Ltd., one of the Howard Group of Companies. The platform is now well advanced in construction and will, it is expected, be ready for launching at the end of September. The contract, which is worth nearly a million pounds with a part payment in dollars, was placed with Steel Structures, Ltd., last November by the DeLong Corporation of America.

The platform, which has been designed by the DeLong Corporation, will contain 3000 tons of steel. It is 190ft long by 106ft wide and 16ft deep. It is completely self-contained with air-conditioned accommodation for a drill crew of thirty men. It has its own generators and a drilling rig, with mud hoppers, capable of drilling down to 15,000ft below the sea bed, and also a helicopter platform. The hull is raised and lowered on four retractable legs, and stands clear of the sea on these legs during drilling operations. When required to move to another position, it is lowered into the sea, and the legs retracted; the platform can then be towed away.

The platform is scheduled for delivery to the Shell Company for use for off-shore drilling operations off the coast of Borneo. It is designed for operations in 125ft of water.

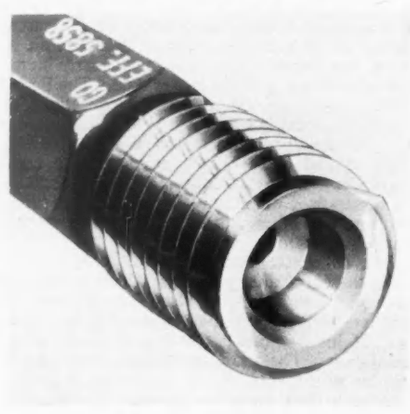
Only two other similar drilling platforms have been built in Europe. These were ordered by the DeLong Corporation from Germany, when firms in England were unable to offer the required delivery. For this third European platform it was decided to carry out the work in the United Kingdom. Since the bulk of the steel for the platform had to be imported from Germany, Southampton was chosen as the site. The Steel Structures, Ltd., works at Southampton were created in two months and work on the platform was started in January last.

Screw Plug Gauges

SCREW plug gauges now being made by Engineers Special Tools, Ltd., Catteshall Lane, Godalming, Surrey, are designed to provide a simple means of recovery when the thread or threads at the leading end have become worn or damaged in service. This recovery is effected by the removal of the worn threads and re-ending of gauges ; and to facilitate this removal the plugs are counterbored to a depth equal to three-eighths of the total threaded length, as shown in the photograph we reproduce.

In introducing these " Multi-Life " gauges, as they are known, the firm points out that many screw plug gauges of conventional design are scrapped because only a short leading length of thread is worn, and when succeeding threads are frequently fully up to the required gauging size. With successive removals of worn threads to an unworn point over the length of the counterbored section effective gauge life can be extended. This is particularly so in the case of fine-pitch thread gauges where six or more worn threads can be removed.

The gauges to this design are being made in all standard thread forms by the company from 4 BA and upwards. Large users of the gauges will be able to grind back and re-end the gauges in their own toolrooms, but to assist other users the maker has instituted a recovery section.



Recoverable screw plug gauge with counterbored end for removal of worn leading threads and re-ending

Industrial and Labour Notes

Capital Cost of Fuel Saving

The fourth annual report of the National Industrial Fuel Efficiency Service (N.I.F.E.S.), which has just been published, says that the work of the organisation was well maintained in the year ended March 31 last. At the same time, the demands made upon the service reflected the fluctuations and uncertainties to which industry was subjected during the twelve months. The total of bookings for the various services available from N.I.F.E.S. was 22·5 per cent greater than in the preceding year, the time taken up in the preparation of heat and power surveys being 1·6 per cent greater.

There is reference in the report to the capital cost of fuel saving. The re-examination of survey work carried out in 1956–57 has provided an opportunity for a closer analysis of the costs of fuel economy and, the report says, firmer estimates of the cost of plant are available now that decisions have been made to proceed with recommendations. The capital investment recommended in the surveys which were re-examined amounts to just over £225,000, and the savings obtainable total nearly 30,000 tons a year after converting the figures for other fuels to the thermal equivalents of coal. The average expenditure to save one annual ton of fuel works out at £7·5 ; if the savings secured by operational improvement alone are omitted since they involve no capital investment whatever, the expenditure required is £9·3 per annual ton. Thus, it is claimed, at present coal costs, the programme will pay for itself within two years.

The report goes on to state that, of the 260 recommendations accepted by industry, seventy-four were concerned with operation and did not require capital expenditure. Another forty were on maintenance and the average expenditure on materials was no more than £110 at each works. The remainder included eighty-four recommendations for new boilers, mechanical stokers or boiler plant auxiliaries, the average capital expenditure to save 1 ton of coal a year working out at £11. The process improvements recommended numbered forty-two and would cost £6·4 to save a ton of coal annually. Finally, insulation of structures or process plant was recommended at twenty of the eighty-seven works and required an average expenditure of £12·9 per ton of coal saved annually.

London Passenger Transport

London Transport has issued to its senior staff a review of its activities in 1957. It puts on record the fact that, for the first time since 1948, the London Transport Executive fully paid its way in 1957, all operating costs and the central charges of the British Transport Commission being met from the year's earnings. But the review adds that the net receipts for 1957 were "only a little more than the minimum contribution to central charges."

The improved financial result, it is stated, was due largely to the temporary transfer of traffic to public services during the Suez period of petrol rationing early last year. For the year as a whole, the number of passengers was 2·3 per cent lower than in 1956. In the second half of 1957, the downward trend of traffic was resumed and it then became evident that the services would have to be reduced in 1958. When petrol rationing ended in May, 1957, congestion of traffic in the London streets reappeared, and this congestion, the review stresses, is the most significant single factor hindering the efficient operation of London Transport road services.

Ultimately, the review continues, new roadways will have to be built at astronomical cost in and across London or, as an alternative which London Transport believes to be more economical, new tube railways will have to be built. The Victoria line, it is asserted, is the most deserving and most urgent of the new tube railways that could be provided. London Transport believes that the construction of this line, Victoria to Walthamstow, is justified now. It is agreed that it will not remove the need for all road improvements in the area it will serve, but, the review observes, experience during the recent bus strike "showed once again that the most effective method of moving people in large numbers into and out of a great city is the underground railway."

Engineering and Shipbuilding Wages

Representatives of the forty unions affiliated to the Confederation of Shipbuilding and Engineering Unions met on Thursday of last week. They had before them a resolution drawn up by the executive of the Confederation following its rejection of the offers of a 3 per cent wage increase put forward by the Engineering and Allied Employers National Federation and the Shipbuilding Employers Federation respectively. The resolution, which was carried, expressed the unions' "indignation at the unrealistic offers" and authorised the executive council to meet the employers again "with the object of seeking an upward revision."

Anglo-Dutch Trade Council

Yesterday, the Federation of British Industries and the Association of British Chambers of Commerce announced the establishment of the Anglo-Dutch Trade Council, with headquarters at The Hague. There has been a Dutch Chamber of Commerce in London since 1890, but hitherto there has been no similar British organisation in Holland.

In an announcement about the new Council, the F.B.I. has pointed out that Holland is the United Kingdom's sixth largest export market. Last year, for example, Holland bought £120,000,000 of British goods, though that was only about 8 per cent of her total imports. Imports from Germany into Holland were well over double the United Kingdom figure. The aims of the Anglo-Dutch Trade Council are : to promote trade between the United Kingdom and the Netherlands and to foster good relations between British manufacturers and the purchasers in the Netherlands of British-made goods ; to assist United Kingdom exporters with advice on the obtaining of agents and market information, arranging for special trade promotion schemes and trade exhibitions, and to make representations where desirable on trade matters to the Netherlands Government and other authorities.

Iron and Steel

A statement by the Iron and Steel Board says that pig iron production in August averaged 221,000 tons a week compared with 272,500 tons a week in August last year. Steel output averaged 299,200 tons a week compared with 373,400 tons a year earlier. Steel production in August was especially low in Scotland and on the North East Coast where, according to the Board, extended holidays were taken as a result of the fall in demand for plate and other heavy rolled products. At present, steel consumption is estimated to be about 5 per cent below last year's level ; the much greater fall in production is attributed to the reduction in stocks and in exports.

For the first time since the end of 1954, stocks of finished steel held by consumers fell during the second quarter of this year, while the stocks held by merchants increased a little. But, after allowing for the fall in stocks, it is estimated that steel consumption in the second quarter was only slightly below that in the comparable quarter of last year. It was, however, appreciably below the level reached in the second half of 1957. The Board says that the decline appears to have continued in the last two months. The main falls in consumption have been in the shipbuilding, railway rolling stock and some of the "intermediate goods" industries.

Engineering Design Conference

On Wednesday, November 12, the Council of Industrial Design, in collaboration with the Birmingham Exchange and Engineering Centre, is sponsoring a one-day conference on the subject of "Industrial Design and the Engineering Industries," at the Birmingham Exchange and Engineering Centre. Mr. Whitney Straight, vice-chairman of Rolls-Royce, Ltd., will preside and the opening address will be by Lord Mills, Minister of Power, who will speak on "The National Importance of Good Industrial Design." It is stated that the aim of the conference is to study the role of industrial design in relation to the engineering industries. It will be attended by an invited audience of senior executives drawn chiefly from Midlands engineering companies. The conference will discuss what steps should be taken to improve the form and function of engineering products. It will also consider how best to make use of the services of industrial designers and how to encourage an appreciation of appearance design among those already employed in the engineering trades. In addition, the conference will examine the introduction of some training in industrial design into engineering courses and the training of industrial designers for the engineering industries.

British Construction Work Overseas

The Board of Trade has stated that, during the twelve months ended March last, British contractors carried out more than £114 million worth of work overseas. This was £12,000,000 more than in the preceding year. According to a survey made by the Ministry of Works, more than sixty British firms undertook work last year in fifty different countries. The value of new contracts obtained during the year totalled £119 million an increase of £17,000,000 on the preceding year, and the value of work outstanding at the end of March this year was £122 million, or £11,000,000 more than in March 1957. The value of work obtained in the sterling area, which includes most countries in the Middle East, increased substantially.

" Mecanelec 58 " Exhibition

No. I

ON Friday, September 12, the Palais du Centre Nationale des Industries et des Techniques at Puteaux (Seine) was inaugurated with the opening of the " Mécanélec 58 " Exhibition. This exhibition, which is devoted to a comprehensive showing of all classes of factory equipment, will remain open until September 21. It is the first of its kind to be held in France ; 650 firms are showing some 4000 tonnes of plant and equipment on a floor area of 40,000 square metres.

In an even more important way, the event marks the beginning of a new epoch in the history of French technical and commercial exhibitions, through the opening of the new Palais du CNIT. The lack of an adequate building for the staging of large exhibitions had been felt by French industry for many years ; in fact, since the demolition, in 1909, of the Galerie des Machines. We shall not say more than a few words here concerning the CNIT, to which we shall refer in a future issue. The vast size of it may be seen from our illustration, which shows it under construction. It is triangular in plan, each side spanning a distance of 218m, and rises to 50m above ground level in the centre, dimensions which make it the largest vaulted structure in the world, with over twice the span of the previous record-holder, the hangars at Marignane which have a span of 101·5m.* The internal floor space totals nearly 100,000 square metres and includes a ground floor of 26,500 square metres over which a second floor of 11,500 square metres is carried on columns spaced 18m apart. This floor is designed for loads of over 1000 kg per square metre. The roof is carried on three supports at its corners. The sides will be glazed. Impressive as the building is, it forms only part of a wider scheme for the development of the western approaches to the centre of the French capital. This long-term plan involves the widening of the Avenue de la Division-Leclerc to 140m and the erection on either side of a number of tall modern buildings for the use of the principal industrial associations and scientific societies.

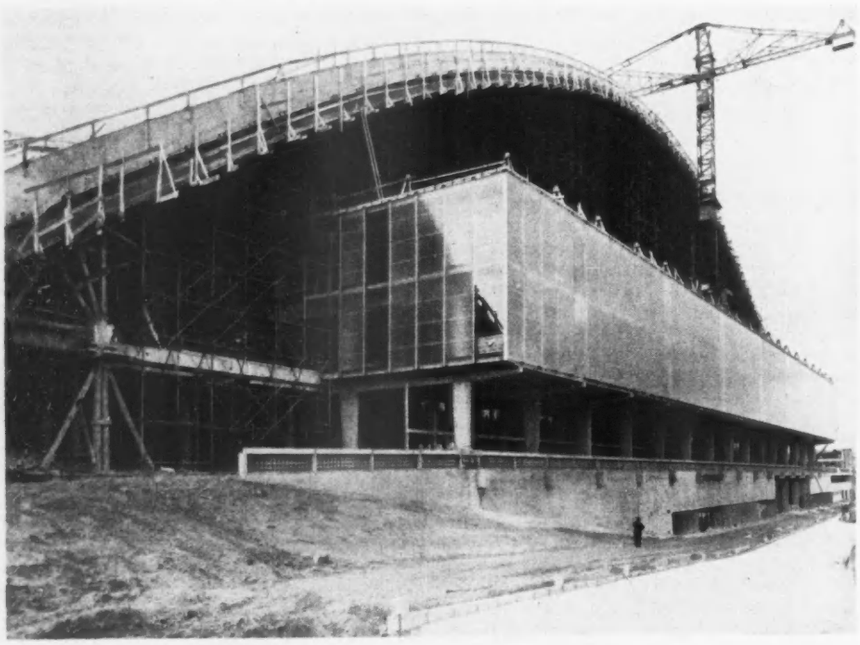
Equipment on view on the 18,000 square metres of stand space of the " Mécanélec 58 " comprises machine tools, mechanical plant, electrical machinery and apparatus, measuring, instruments and devices for the control of industrial processes as well as components nnd fittings. It has been the aim of the organisers to show as many of the exhibits as possible in actual operation, so that each stand forms, as it were, a small sector of a factory.

Mechanical equipment occupies 13,000 square metres of stand space, of which, 5000 square metres are reserved for machine tools, both French and foreign, a total of 160 exhibiting firms. Heavy machine tools are being exhibited in a hall of 2500 square metres specially equipped for this purpose with a 20-tonne travelling crane. Other " mechanical " aspects include light machine tools, hand tools, welding, industrial ventilation and air conditioning pumps and compressors, ovens and furnaces, power transmission, and fittings. The instrumentation and control sector shows a very full range of products of French, German and British firms, on 2000 square metres of stands. Electric and electronic instruments for measuring, control, and automation are on view, as well as meters for all fluids, metering and weighing devices and pyrometers. All techniques—mechanical, optical, pneumatic, hydraulic, electric and electronic—are represented as applied to problems of production, research and safety.

Electric equipment is exhibited by some 100 firms and represents a complete cross-section of the electrical products which are met with in industry, from motors and generators to installation equipment and material, from electronic control instruments to apparatus for non-destructive testing.

The Centre National de l'Automatisation was founded recently by the mechanical engineering and electrical and electronic manufacturers' federations, under the ægis of the Commissariat Général à la Productivité. At the Mécanélec this organisation is making its début before the public, showing by means of examples the scope and progress of automation.

(To be continued)



The Palais du Centre des Industries et des Techniques (CNIT) at the Rond-Point de la Defense, Puteaux, under construction. The illustration shows the building as seen from Avenue de la Division Leclerc, near the corner of the Avenue Perronet

* See *Le Génie Civil*, December 15, 1951.

Important Result from CERN Synchro-Cyclotron

It is reported that the 600 MeV synchro-cyclotron,* which has been operating at Meyrin, near Geneva, since late last year, has just made its first major contribution to physics. Although the result contradicts former findings elsewhere, it is in harmony with theoretical prediction and is very much the result that physicists have been wishing to arrive at. The particular virtues of the CERN† accelerator are thought to justify faith in the outcome of what is described as having been a crucial experiment.

One of the fundamental particles, known as the π-meson, was observed in cosmic rays about eleven years ago. It was found that the π-meson decays as follows :—

$$\pi^+ \rightarrow \mu^+ \rightarrow e^+$$

where μ denotes a μ-meson and the end product is a positron. The mean life of the π-meson is $2{\cdot}6 \times 10^{-8}$ seconds, and of the μ-meson is $2{\cdot}2 \times 10^{-6}$ seconds. The mass of a meson is intermediate between that of an electron and a proton, and it is therefore clear from the above that some mass is " lost " in the transformation; the equivalent of this mass appears as energy. Not long after the discovery of the π-meson it was predicted on simple theoretical grounds that once in every 10,000 times the decay from π-meson to positron should occur directly, without transition through the μ-meson state. Experiments at the Universities of Columbia and Chicago failed to confirm this. Since the reasoning that led to the prediction was straightforward, this failure threw doubt on the theoretic foundations of the study.

The discovery,‡ made in the U.S.A. fairly recently, that parity is not always conserved on the nuclear level, greatly simplified understanding of certain phenomena. A few major difficulties have remained, however, one of them being the failure to detect the direct decay of a π-meson into a positron. The experiment by CERN is now reported to have resolved this problem. π-mesons produced by the synchro-cyclotron have been observed, and the direct decay detected. The frequency of direct decay is not quite what the theoreticians would have it, but the number of corrections required for the experimental apparatus at Meyrin is sufficient for the research team involved to feel confident that eventually the theory will be confirmed quantitatively as well as qualitatively. The group responsible for the experiment consisted of T. Fazzini (Italy), G. Fidecaro (Italy), A. W. Merrison (U.K.), H. Paul (Austria), and A. V. Tollestrup (U.S.A.).

Launch of T.S.S. " Rotterdam "

On Saturday, September 13, Her Majesty, the Queen of the Netherlands, gave the name " Rotterdam " to the new flagship of the Holland–America Line when launching the liner from the yard of the Rotterdam Dockyard Company and from the same ship from which Her Majesty Queen Wilhelmina launched the " Nieuw Amsterdam " in 1937. The liner has a length of 748ft, a beam of 94ft, a gross tonnage of about 37,000 tons and at launch had a weight of 18,500 tons. There have been four previous ships bearing the same name and the first was built in 1872 and was also the first ship of the Holland–America Line. When completed the ship will have a profile differing from other Atlantic liners (there will be no funnels) have twelve decks and provide accommodation for 1400 passengers in two classes and a crew numbering 750. The ship will be fully air-conditioned and equipped with Denny-Brown stabilisers. Propulsion will be by two sets of Schelde-Parsons turbines developing a total of 35,000 s.h.p. and taking steam from four Schelde-Combustion boilers. It is expected that the ship will sail on her maiden voyage in the autumn of next year.

* See THE ENGINEER, October 11, 1957, page 538, and July 18, 1958, page 105.

† CERN is the European Organisation for Nuclear Research, an international body in which the U.K. takes a major part.

‡ See THE ENGINEER, February 28, page 340.

High-Temperature Research at the National Bureau of Standards

BY OUR AMERICAN EDITOR

No. III—(*Concluded from page* 431, *September* 12)

Recent developments in high-speed flight, rocket propulsion, and nuclear reactors have raised operational temperatures from well below 1000 *deg. Cent. into a range up to* 4000 *deg. Cent. in which there had been little scientific or industrial experience. Until recently the work on materials done by the National Bureau of Standards was largely confined to the more conventional temperature ranges. However, a high-temperature research programme has grown quickly, mainly as a result of the Bureau's efforts to meet its assigned responsibility for devising precise measurement methods and determination of the basic properties of materials. The high-temperature research programme may be divided into three groups :* (1) *Studies of structure ;* (2) *determination of properties and constants of materials ; and* (3) *development of methods and instrumentation for high-temperature measurements.*

High-Temperature Strain Gauges

A PROGRAMME aimed at improving existing strain gauges and developing new designs for high-temperature use is being carried on in three laboratories at the National Bureau of Standards under the sponsorship of the U.S. Navy, Air Force and Atomic Energy Commission. The work includes the improvement of ceramic-bonded gauges, the development of strain-sensitive evaporated film gauges, and the evaluation and calibration of presently used and proposed strain-measuring devices. At present, gauges are urgently needed to perform satisfactorily up to 1000 deg. Fah., and in the near future instruments for use up to 2000 deg. Fah. will be in demand. These gauges must be suitable for both static and dynamic tests on a wide range of different materials under both steady and transient temperature conditions.

Strains at or near room temperature are usually measured with paper-backed, wire-resistance gauges of the Baldwin " SR-4 " type. The gauges are cemented to the structure with an organic resin. When a load is applied, the wire filament of each gauge is deformed by approximately the same amount as the surface to which it is cemented. This deformation results in a change in electrical resistance of the wire filament. A knowledge of gauge characteristics permits such changes to be converted to strain. The maximum temperature at which the paper-backed gauge will operate is about 350 deg. Fah. Above this temperature, the organic cements deteriorate and will no longer transmit the full amount of strain to the filament wire. For high-temperature applications, the Bureau is attempting to solve this deterioration problem in two ways : by modifying the usual type of resistance strain gauge through the use of ceramics in place of organic materials, and by developing a gauge which, in one form, eliminates cements by employing directly deposited conducting films instead of wires.

Ceramic-Bonded Gauges

The work on ceramic-bonded gauges has been under way in the enamelled metals laboratory for the past three years, under the joint support of the U.S. Navy Bureau of Aeronautics, the Wright Air Development Centre and the U.S. Navy Bureau of Ships. From this investigation has resulted a new gauge called the " 5B " design, which gives usable static-strain data up to 800 deg. Fah. The gauge consists of two straight wires, 0·001in in diameter by $\frac{3}{8}$in in length, welded to narrow strips of Inconel foil, 0·002in thick (Fig. 14). The Inconel strips, which form the leads and shunt at the bottom of the gauge, are crimped to a backing of asbestos paper previously coated with a thin layer of ceramic cement. When the gauge is used, it is cemented to the surface of the test structure with the same ceramic cement. No precoating of the test surface is necessary. The wet cement does not completely flow out from under the Inconel strips when the gauge is pressed ipto position ; hence, there is no electrical shorting to ground. Measurements have shown that the filament wires are from 0·001in to 0·002in from the test surface after the gauge has been applied. One advantage of the device is that it is completely prefabricated and therefore can be attached to many recessed areas of the test structure. Most commercial gauges are mounted on a resin backing and this backing must be removed before the gauge is embedded in the ceramic cement. This requires considerable skill on the part of the operator. Such gauges also require that a ceramic precoat be applied to the metal.

The maximum temperature at which the " 5B " gauge is usable is limited by the decrease in resistance stability of the wires with temperature and by loss of resistivity in the ceramic cements. To extend the upper range of temperature, attention is being focused on cements which show higher electrical resistivity at high temperatures. A cement has recently been developed which has improved properties in the range 1000 deg. to 1800 deg. Fah. Ceramic coating of the alloy filament is also being investigated both to improve resistance stability of the wire and to aid the insulating cements in preventing electrical leakage to ground.

Strain-Sensitive Film Gauges

Another approach to the development of a high-temperature strain gauge is being made by the Bureau's mechanical instruments laboratory. The technique under consideration involves the use of deposited metal or alloy films in place of attached filaments as strain gauge elements. Investigations of the suitability of such films for use as high-temperature strain gauge elements are being carried out under a programme sponsored by the Atomic Energy Commission. In the proposed gauge, the film will be deposited on to a thin non-conducting substrate which can be bonded to test surfaces. Alternatively, the film may be deposited on an area of the test surface which has been rendered non-conductive, thus eliminating the use of cements or adhesives. Electrical contacts bonded to the test surface at either end of the film will permit strain measurements to be made (Fig. 15).

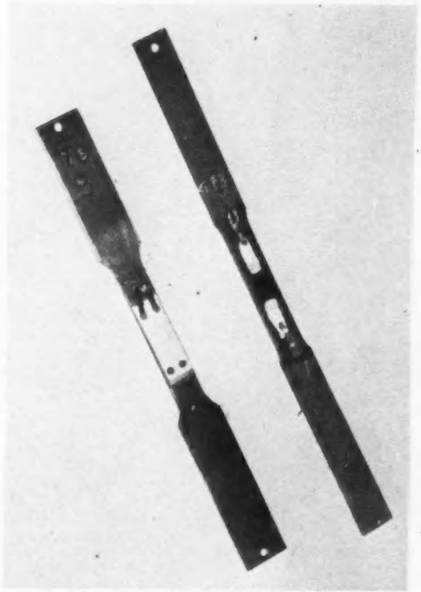
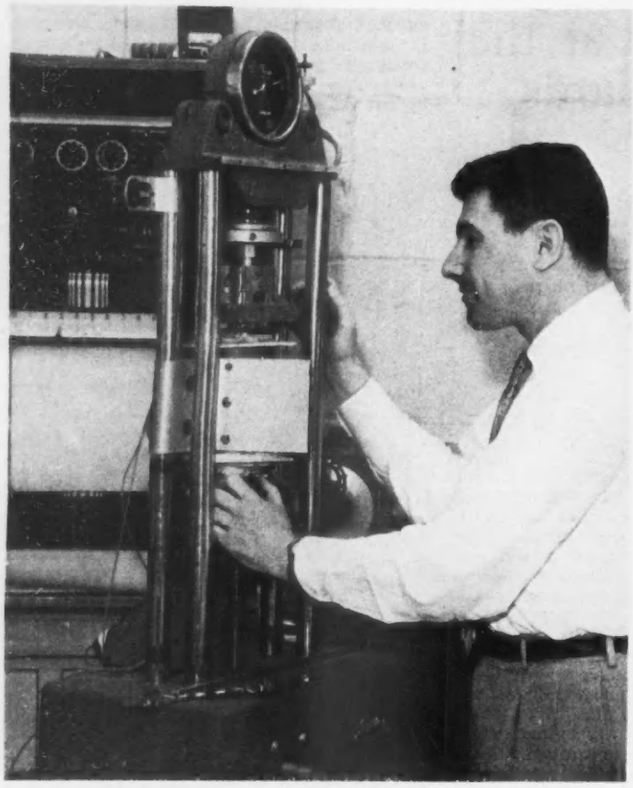


Fig. 15—Strain-sensitive film deposited directly on test strip (left) and ceramic-coated asbestos-backed gauge bonded to test strip (right)

In developing an evaporated film strain gauge for use at temperatures from 1000 deg. to 2000 deg. Fah., several factors must be considered. Of prime importance is the choice of film material. The film must be strain-sensitive, capable of adhering to the test surface, and chemically and physically stable at high temperatures. The test surface must be electrically non-conducting. If gauges are to be used within atomic reactors, a further restriction is placed on the choice of film and base material, since both must be unaffected by nuclear radiation. In studies of the resistance-strain properties of films evaporated from twenty-two metals, the Bureau found all films to be strain-sensitive. These tests were conducted on films deposited on suitable test strips by a vacuum evaporator (Fig. 17). The foundations were an anodised aluminium strip coated with silicone resin and having silver contacts and a porcelain-coated steel strip with platinum contacts. The test strip with its film gauge was subjected to strain, and

Fig. 14—Spot welding of strain gauge elements on a ceramic-coated asbestos backing



Figs. 16 and 17—(Left) Tensile testing apparatus with shielded furnace used to develop evaporated-film strain gauges. (Right) Vacuum evaporator for the preparation of evaporated-film strain gauges, with powdered metal being placed in a tube leading to the boat container

the resistance-strain relationship determined. The strain-sensitivity or gauge factor of the test films was found to depend strongly on film specific resistance or thickness ; for the thinner films strain sensitivities several times those of the bulk material value were observed. The relationship between gauge factor and film specific resistance was similar in form for all metals tested. Further tests showed that the gauge factor is a true property of the film, independent of contact, substrate, or atmospheric effects.

Although several of the elementary metals gave satisfactory resistance-strain curves at room temperature, at higher temperatures resistance and gauge factor were found to decrease. Time also had a deleterious effect. By electron microscope and electron and X-ray diffraction methods, these property changes were seen to result from changes in structure. For these reasons attention was turned to the development of an alloy that would retain its resistance properties at elevated temperatures and over long time intervals. Satisfactory results up to 750 deg. Fah. (the maximum temperature at which tests have been conducted) have been obtained in preliminary tests with a film evaporated from a mixture of iron, aluminium and titanium powders

In addition to strain-sensitivity and durability, material suitability depends on factors such as resistance-strain stability, reversibility and linearity. Some drift, hysteresis and non-linearity were noted in all resistance strain curves for elementary metals. However, the alloy appeared to be stable under all test conditions. Before evaporated-film gauges can be applied directly to structural test surfaces, some means of adequate bonding between contacts and insulating coatings must be developed. Transferable film gauges on foil foundations have been produced and found suitable for use with organic cements up to 450 deg. Fah. However, loss in shear strength of the cement limits their use at this temperature. Ceramic cements do not as yet offer a solution as they do not cure properly when confined between two non-porous surfaces.

Strain Gauge Evaluation

Since resistance strain gauges cannot be individually calibrated prior to use, their usefulness depends upon the characteristics of the gauges being accurately known. At elevated temperatures these gauges often develop deficiencies which are not necessarily predictable, but which may be serious enough to limit the usefulness of the gauges. To determine the performance characteristics of available gauges, to define the conditions under which meaningful measurements may be made with the gauges, and to point out areas where further gauge development is needed, an evaluation facility has been established at the Bureau under the sponsorship of the U.S. Navy and Air Force. Equipment and procedures designed by the Bureau's engineering mechanics laboratory are now available for the comprehensive evaluation of gauges at temperatures up to 1000 deg. Fah. Some of these tests have been carried out at maximum temperatures up to 1500 deg. Fah. Tests include the determination of gauge factor, resistance drift at elevated temperatures, resistance-temperature relationships, the effects of transient heating on resistance characteristics and the effects of storing at various humidity levels.

In obtaining gauge factor values, the resistance gauge is attached to a uniform test strip in a region of controlled temperature (Fig. 18). Change of gauge resistance as the strip is strained is measured with a Wheatstone bridge circuit capable of detecting a relative change of resistance of one part per million. Strain to which the resistance gauge is subjected is measured with an optical strain gauge which can be read through a window in the temperature-controlling furnace. After corrections for temperature fluctuations, elapsed time, and instrument calibration are applied to the resistance-strain data, the gauge factor is determined as the slope of the curve of relative change of resistance versus strain. The departure of the experimental points from a straight line shows the non-linearity of gauge response. Hysteresis and zero shift are also shown by data taken during increasing and decreasing loading.

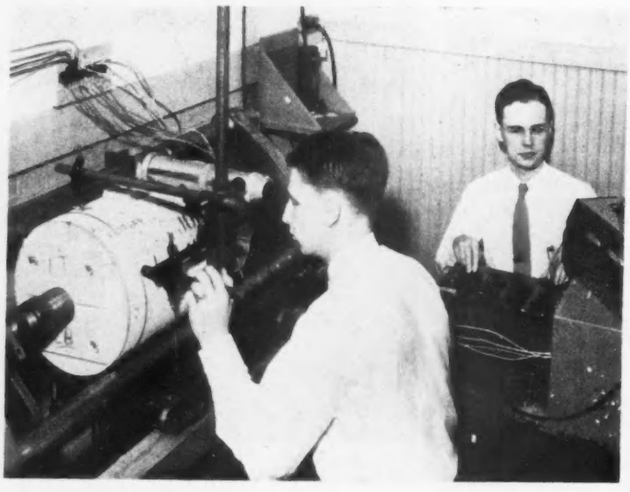


Fig. 18—Determination of strain gauge factor at elevated temperatures using an optical strain gauge which spans the resistance strain gauge under test

The determination of change of gauge resistance with time at elevated temperatures is necessary since such drift can cause serious error in static strain measurements. To determine drift, a gauge attached to a stainless steel test strip is inserted into an oven preheated to the desired test temperature. When the test strip has come to the oven temperature, the apparent strain indicated by the gauge is noted at frequent intervals for at least one hour. Such drift measurements have been made at temperatures up to 1200 deg. Fah. To apply corrections for temperature fluctuations during gauge factor and drift tests temperature coefficients of resistance

are required. These values are obtained by causing the temperature of the gauge to increase a few degrees and to decrease a similar amount while the resistance change is noted. The temperature coefficient can be obtained from the simultaneous equations involving resistance change, temperature and time. This method assumes that the temperature coefficients and drift rates are constants and therefore independent of small temperature variations, of direction of temperature change and of time. Since these assumptions may not always be valid, temperature coefficients are also determined as the slope of a line drawn tengentially to the resistance-temperature curve at the temperature under consideration. Curves recorded during heating rates of about 5 deg. Fah. per second serve as a basis for these determinations.

Because many of the uses for high-temperature strain gauges involve transient heating, a study of the effect of rapid temperature changes on the performance characteristics of the gauges is conducted. Gauges are subjected to repeated heating and cooling between 80 deg. and 1500 deg. Fah. at rates of about 60 deg. Fah. per second. Two banks of radiant heaters provide the heat ; an air stream from a centrifugal blower accomplishes the cooling. During such temperature cycles the relative change of resistance of the gauge is recorded as a function of the test strip temperature. To determine the effects of storage at different humidities, gauges in three conditions—as received from the manufacturer, embedded in uncured cement and embedded in cement and cured—are placed in closed containers with saturated salt solutions which produce atmospheres with relative humidities of about 12, 55 and 93 per cent. The resistance of each gauge is then measured at suitable time intervals, and the change of resistance is taken as evidence of the detrimental effects due to storing. No gauge as yet developed is entirely suitable for use at elevated temperatures. However, work on the improvement of existing gauges and the development of new gauges promises to extend measurements into the high-temperature region. In the meantime, a knowledge of characteristics of presently-available gauges, as provided by the Bureau's evaluation centre, may make possible meaningful strain measurements at intermediate temperatures.

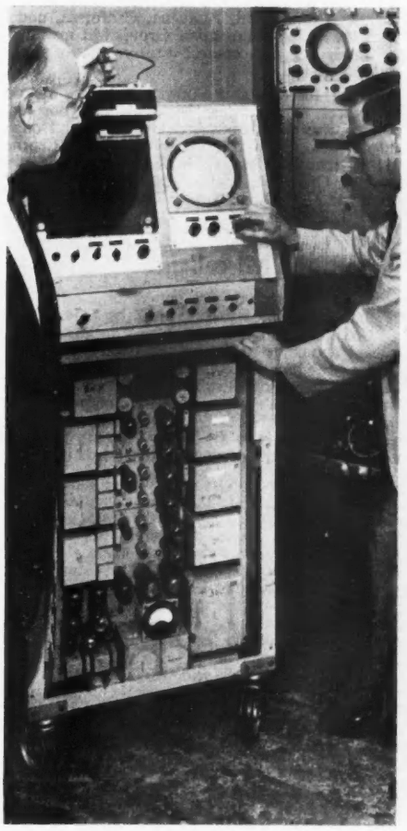
Digital Simulation in Speech and Television Research

RECENT work at the Bell Telephone Laboratories indicates that the use of general purpose digital computers in the simulation of new coding and transmission devices shows promise of accelerating and broadening speech and television research. For many laboratory studies it is now possible to avoid the construction of very complicated equipment through the use of such simulation.

Complex experimental apparatus must often be built to test theories or design concepts in speech and television video research. This construction is costly and time-consuming. In addition, in the experimental stage, it is frequently difficult to distinguish equipment errors from theoretical deficiencies. The simulation of new devices by large-scale digital computers can greatly reduce expense and time lags, and thus make it easy to investigate a large number of approaches to coding and transmission problems. It even becomes feasible to investigate highly speculative methods which might otherwise have to be ignored. One of the greatest virtues of simulation, however, is versatility, since computers can simulate any explicit operation on a speech or video signal.

In speech research, speech is sampled, each sample is " quantised " into ten bits or 1024 amplitude levels and delivered to a magnetic tape recorder. These coded samples are recorded in seven parallel tracks with 200 characters to the inch of tape. These tapes are then fed into the computer, where they are processed according to preassigned programmes based on the coding or transmission scheme being investigated. The processed signals are then re-recorded, decoded and played back for analysis and listener evaluation. The computer memory requirements for speech processing are severe, due to the large amount of data generated by even a short section of speech. Rapid access memory units must have a capacity of several seconds of speech to be useful. For example, an 8000 thirty-two bit word memory can conveniently hold only about 2·4 seconds of speech, at a sampling rate of 10,000 ten-bit samples per second.

A speech transmission scheme known as the " Extremal " method, has been studied at the Bell Laboratories extensively by simulation and illustrates graphically the advantages of the new technique. In its simplest form, only the extremes, or peaks and valleys, of a speech wave are sampled. The amplitudes and time of occurrence of these points are then transmitted, instead of a detailed representation of the entire wave. At the receiver, an approximation of the speech wave is generated by interpolating a suitable mathematical function between these points. A listener evaluation of the simulated speech produced in initial tests showed that intelligibility is high—above 90 per cent sentence intelligibility—but that the quality is somewhat below that of commercial telephones. This " Extremal " programme operated on about a 20 : 1 time scale ; for the results reported so far, a total of five minutes of speech was synthesised. Including " de-bugging," about three hours of computer time was expended at a cost of 1500 dollars. About four man-months of time was spent, partly in programming, but mostly in determining what to investigate. These figures are substantially less than those required to build an actual laboratory model to perform the same function, involving roughly one and a half man-years and 50,000 dollars in equipment costs. This model also would have been much harder to " de-bug," and would have been relatively inflexible. Digital simulation has been applied to a number of other speech problems at the Bell Laboratories. These problems include the design and evaluation of delta-modulation coders, pulse-code-modulation systems, detection of vocal pitch and automatic recognition of speech.



Reproduction of a television picture following processing by computer simulation at the Bell Telephone Laboratories

Picture coding research has also been carried on by computer simulation, and has been used to evaluate a number of proposed television coding schemes and to improve others. In order to hold machine time and memory requirements to a reasonable level, the system has used an input picture of 100×100 elements, corresponding to an area about one-twenty-fifth that of a conventional television frame. This 10,000 element " window " has proved to be of sufficient size to allow a critical evaluation of the processed images. For typical coding schemes, the total computer time required is five to ten seconds per picture. A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2·4 seconds. Each picture dot is " quantised " to ten-bit accuracy, providing 1024 amplitude levels and recorded in the same form as the speech samples described above. The resulting signal is rooted, mixed with a synchronising waveform in the conventional manner, and band limited to 2500 c/s. In playback, the computed picture signal is converted back to analogue form. It is then passed through a low-pass filter and displayed on a monitor with two kinescope tubes. One of these tubes has a slow phosphor for direct viewing, while the other has a fast phosphor for photography.

A coding scheme which may have widespread significance in television transmission, known as " Predictive Quantising," has been studied by both simulation and conventional methods. This scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves " quantising " the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the " quantising " staircase allows the use of a smaller number of total levels and thus reduces the channel capacity requirements.

A limiting case of predictive " quantising," in which the predictor is simply a one-sample delay, has been tested both with the simulation equipment described and with standard 525-line television and found to afford a picture not significantly degraded from the original and requiring only three bits per picture dot. Computer simulation has provided a method for the investigation of a number of variations of predictive " quantising," as well as other methods of coding. Its use in picture analysis for pattern recognition and for statistical computations is also being studied at the Bell Laboratories.

Gas Turbine Licence Agreement

THE Clark model " 302 " and " 305 " gas turbines will be available for currencies other than dollars as a result of a licence agreement recently concluded between Dresser A.G., European subsidiary of Dresser Industries, Inc., Dallas, Texas, and Armstrong Siddeley Motors, Ltd., of the Hawker Siddeley Group. Manufacturing royalties and sales commissions will be paid in hard currency to Dresser A.G. Armstrong Siddeley already hold licences from the Garrett Corporation to build AiResearch gas turbines for aircraft auxiliary applications.

The engines and all components will be interchangeable with the products of the Clark Bros. Company, Olean, N.Y. They are heavy industrial prime movers of a simple cycle, distinguished by a single reverse flow combustor parallel to the gas generator shaft : heat exchangers are available. The " 302 " has a two-stage power turbine giving 9300 h.p. at 3600 r.p.m. and the " 305 " a single-stage turbine of 8700 h.p. at 5000 r.p.m. : in both cases the gas generator (which can be supplied alone where quantities between 60–130 lb per second of hot combustible gas are required) runs at a nominal 5000 r.p.m. Applications particularly associated with these units are the driving of 60-cycle alternators and of centrifugal gas compressors.

Personal and Business

Appointments

MR. JOHN PARSONS has been appointed a director of Richard Lloyd, Ltd.

MR. G. MORRIS has been appointed foundry works manager of Head Wrightson Iron Foundries, Ltd.

MR. R. W. MARSHALL has been appointed Nottingham area manager for Dewhurst and Partner, Ltd.

MR. BERNARD A. CHRISTIE has been appointed home sales manager of Coventry Climax Engines, Ltd.

BIRFIELD INDUSTRIES, Ltd., announces that Mr. W. B. Broadbent, A.M.I.Loco.E., is joining its railway division on October 1.

MR. E. PLAYER and MR. F. A. W. LIVERMORE have been appointed joint managing directors of the Midland Motor Cylinder Company, Ltd.

BABTIE, SHAW AND MORTON, have appointed Mr. D. J. Coates, A.M.I.C.E., in charge of their London office at 19, Grosvenor Place, London, S.W.1.

MR. S. H. GRIFFITHS, head of John Thompson, Ltd., group research laboratories, has been appointed a director of John Thompson (Wolverhampton), Ltd.

METAL AND PIPELINE ENDURANCE, Ltd., announces that Mr. Morton Gordon has been appointed acting chief welding engineer in succession to Mr. R. B. Whalley.

THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD has announced that Mr. Andrew Menzies, M.I.E.E., has been appointed area manager for its north Caledonia area in place of the late Mr. A. Clark.

LONDON TRANSPORT announces that Mr. J. W. Wicks, works manager (buses and coaches) has, in addition to his present responsibilities, assumed overall responsibility for the trolleybus works, following the retirement of Mr. J. Schofield.

A. REYROLLE AND CO., Ltd., has announced the following appointments : Mr. J. Christie, technical director ; Mr. H. Leyburn, head of research ; Mr. W. Gray, chief engineer ; Mr. D. F. Amer, chief designer, and Mr. A. F. B. Young, assistant to the technical director " Advanced Development."

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that Mrs. Alison Munro has been appointed under secretary of the air services and civil aviation international relations group of divisions of the department in the place of Mr. M. M. V. Custance, who was appointed a deputy secretary on August 1.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., announces that Mr. R. F. Harvey, export manager, has been appointed general sales manager (cables). Mr. E. H. Gosling, continues as home sales manager, and Mr. J. L. Woollett, A.M.I.Mech.E., A.M.I.E.E., has been appointed export sales manager (cables). The north London area will in future be managed by Mr. H. T. Walker, the central London area by Mr. A. A. W. Barnes, and the south London area by Mr. B. Keefe.

WINSTON ELECTRONICS, Ltd., has announced the appointments of four specialist regional technical sales engineers : Mr. K. P. Reynolds, Yorkshire, Lancashire, Cheshire and the north ; Mr. P. Reeves, Derbyshire, Nottinghamshire, Lincolnshire, Staffordshire, Shropshire, Worcestershire, Northamptonshire, Leicestershire and Rutland ; Mr. V. Diederichs, London (south of the Thames), Gloucestershire, Oxfordshire, Wiltshire, Berkshire, Hampshire, Dorset, Sussex, Kent and Surrey ; Mr. D. A. Jamison, London (north of the Thames), Cambridgeshire, Hertfordshire, Buckinghamshire, Bedfordshire and Middlesex.

Business Announcements

PLOWRIGHT BROTHERS, Ltd., states that its London office is now at 197, Knightsbridge, S.W.7 (telephone, Knightsbridge 2525-7).

BENNIS COMBUSTION, Ltd., Brettenham House, Lancaster Place, Strand, London, W.C.2, announces that its new telephone number is Covent Garden 1512.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., announces that the address of its lamp sales department is Melton Road, Leicester (telephone, Leicester 61531).

CONSTRUCTORS JOHN BROWN, Ltd., states that it is moving to new offices at CJB House, Eastbourne Terrace, Paddington, London, W.2 (telephone Ambassador 8080) on September 20.

MR. OLIVER GREGORY, export sales manager of Griffen and George (Sales), Ltd., has left by air for a tour of northern European countries. He is calling on the group's agents in Germany, Denmark, Finland, Sweden and Norway.

WHIFFEN AND SONS, Ltd., states that its executive and sales organisations are now concentrated entirely at its Loughborough factory. The publicity and advertising department will remain at Fison House, 95, Wigmore Street, London, W.1.

THE VISCO ENGINEERING COMPANY, Ltd., Stafford Road, Croydon, has appointed Swansea Sheet Metal Engineers, Ltd., Albion Works, Morriston, Swansea, as its agent for south and central Wales and Monmouthshire and Gloucestershire.

ELLIOTT-AUTOMATION, Ltd., announces that it has entered into arrangements with Consolidated Electrodynamics Corporation, Pasadena, California, under which the Elliott-Automation Group will manufacture analytical and control instruments of Consolidated design.

RHODES, BRYDON AND YOUATT, Ltd., has opened new offices to cover the Midlands and northern counties areas : Midlands Area Office, Griffin House, Ludgate Hill, Birmingham, 3 (telephone, Central 8911/2); manager, Mr. C. M. Saunders. Northern Counties Office, 60, Highbury, Jesmond, Newcastle upon Tyne, 2 (telephone, Newcastle 81-4722); manager, Mr. M. J. B. Hodgson.

Miscellanea

FLEXIBLE COUPLING.—In our description of the " Fenaflex " flexible coupling made by J. H. Fenner and Co., Ltd., Marfleet, Hull, which appeared in the issue of September 5, it was incorrectly stated that the tyre was bonded to the twin flanges. Actually, the tyre has tension members bonded to it and the flanges are separate items, which are fastened to the shafts by " Taper Lock " units. Further, the tyre is split transversely to facilitate replacement without need for moving the driving or driven machines.

TELEVISION FOR " PLUTO."—We are informed by E.M.I. Electronics, Ltd., that a high-definition, closed-circuit television system, developed for use in nuclear reactors, began operating recently at the Atomic Energy Authority's establishment at Harwell. The cylindric camera unit is 3in in diameter and approximately 48in long. It can be lowered through an inspection cover directly into " Pluto." A transparent tubular case protects it. A remotely controlled mirror in front of the lens enables the operator to view all parts of the interior, which has been specially illuminated. Switched scan reversal circuits have been incorporated to compensate for the lateral inversion of the mirror image. The E.M.I. camera channel works on the 625-line system, and is said to employ the latest construction techniques.

FLUXES FOR SUBMERGED-ARC WELDING.—Under the generic name of " Muraflux," Murex Welding Processes, Ltd., Waltham Cross, Herts, states that it is producing a group of new powder fluxes for submerged arc welding. " Muraflux A " is the first of these, a general-purpose flux for mild steel. It can be used on either a.c. or d.c. supplies, with currents up to 900A, on all machines suitable for submerged-arc welding. The flux may be employed with a mild steel filler wire containing approximately 2 per cent manganese or with a normal mild steel wire. Both types of wire, known as " Murawire W1 " and " Murawire W2," respectively, can be supplied by Murex Welding Processes, Ltd. When used with " Murawire," " Muraflux A " is reported to produce good welds and it can be employed for Class 1 work. In conjunction with " Murawire," the flux has been granted approval by Lloyd's Register of Shipping and is accepted by the Ministry of Transport. " Muraflux A " is suitable for either the single-pass or multi-pass welding of various joints in mild steel, as well as plug welds and building-up worn mild steel parts. Good penetration can be obtained, and unfused flux can be recovered and used again.

MEASURING THE VISUAL DENSITY OF SMOKE.—Following the introduction of the Clean Air Act, and the increased interest in prevention of air pollution in Great Britain, many cities and towns are declaring certain areas to be smokeless zones. A need for an instrument to estimate the density of smoke has arisen. The " Smokescope," now being produced by Mine Safety Appliances Company, Ltd., Queenslie Industrial Estate, Glasgow, is an optical instrument for this purpose. Smoke control is usually based on an established maximum desnity, and density cards are available to check by. The cards are normally black rulings on a white ground, and they are set far enough away from the observer to make the chart appear only as a shade of grey. Smoke density is then estimated by selecting the chart which is nearest in density to the observed smoke. The limitations of this method are : (1) Variations in the background against which the smoke is seen ; (2) Variations in the illumination of the charts ; (3) Difference between the illumination of the chart and of the chimney ; (4) The need for the observer to change the focus of his eyes. The " Smokescope " is claimed to be the result of long study and research towards minimisation of these errors. Designed in the style of binoculars, but with only one viewing aperture, the instrument contains a standard film disc of smoke density. This is viewed against the background adjacent to the chimney, so that the film receives light from the same source as does the smoke. Any background differences affect both the smoke and the disc so they are less important. Ambient light plays no part. A lens projects a virtual image of the disc to a distance equivalent to that of the smoke. The observer thus makes comparison without changing the focus of his eyes. The disc is based on the Ringelman Chart Nos. 2 and 3.

INDUSTRIAL FILMS.—A new colour film produced for the Hot Dip Galvanisers' Association entitled " No Rust Here," was shown for the first time in London recently. The aim of the film is to demonstrate how hot dip galvanising gives reliable and lasting protection to iron and steel against corrosion. Typical examples of the protection afforded by galvanising include the 702ft high Crystal Palace television tower, pylons and overhead structures used in railway electrification schemes, and pilot boats at the Hook of Holland. The film runs for twenty minutes and is available on loan in 16mm size from the Zinc Development Association, 34, Berkeley Square, London, W.1. A second film, also shown recently, entitled " Progress in Wheel Manufacture," has been produced by the technical film unit of the Dunlop Rubber Company, Ltd. The film describes how the introduction of new machinery and automatic techniques has greatly increased the manufacture of wheels and rims by the Dunlop Rim and Wheel Company, of Coventry. Until the installation of the new machinery, with its economical use of labour and raw materials, both rims and wheels were in small batch production. The film runs for fourteen minutes and is available on loan from the Dunlop Film Library.

MAGNETIC SWARF SEPARATORS.—An improved design of dual-drum separator for the reclamation of non-ferrous swarf containing ferrous contamination is now being made by Electromagnets, Ltd., Bond Street, Birmingham, 19. The separator comprises two magnetic drums embodying " Alcomax " high efficiency permanent magnetic alloy units so arranged that the ferrous contamination extracted from the non-ferrous is retained on the drum shell until it rotates out of the non-ferrous feed and discharges the former into a separate container. Vibratory feed trays, actuated by out-of-balance rotary motors, provide a consistent and steady feed of swarf on to the drums. Swarf passes from an overhead hopper (which can be fed by a chain and bucket elevator) into the primary feed hopper, which regulates the feed on to the first feed tray by means of a rack and pinion operated regulation gate. This first drum removes the majority of the contamination, the slightly contaminated non-ferrous passing forward on to the second tray which then feeds it on to a second drum which is designed to search out the non-ferrous contamination which may be entangled with the non-ferrous. As an additional safeguard to ensure that any fine iron which may be attached to non-ferrous oily swarf is removed, a final permanent magnetic chute is fitted over which all the non-ferrous material passes.

SPACE MEDICINE SYMPOSIUM.—A Symposium is being organised by the British Interplanetary Society, with the co-operation of the Royal Air Force Institute of Aviation Medicine. It will be held at the headquarters of the British Medical Association, B.M.A. House, Tavistock Square, London, W.C.1, on Thursday and Friday, October 16–17, 1958. It is intended to bring together medical research workers in the fields of space- and aviation-medicine, designers of high-altitude aircraft and equipment, and scientists interested in upper-atmosphere and extra-terrestrial conditions, to discuss man's reactions to the conditions that would be encountered in space or on other planets and the equipment that will be required for survival under these conditions. Papers at present scheduled for presentation include : " The Man-Machine System in Space Vehicles," by Commander George Hoover (U.S. Office of Naval Research) ; " Vision and Orientation at Extreme Altitudes," by Squadron Leader T. C. D. Whiteside (R.A.F. Institute of Aviation Medicine) ; " Impairment of Human Performance in Control," by K. F. Jackson (R.A.F. Institute of Aviation Medicine) ; " Some Consequences of Weightlessness and Artificial Weight," by Dr. M. P. Landsberg (National Aeromedical Centre, Soesterberg, Netherlands). Details are available from the Secretary of the Society, 12, Bessborough Gardens, London, S.W.1.

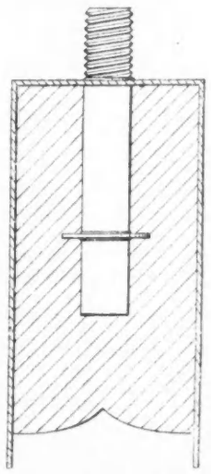
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

METALLURGY

800,112. January 23, 1956.—THE ADDITION OF VOLATILISABLE METALS TO CAST IRON AND STEEL, Magnesium Elektron, Ltd., Lumm's Lane, Clifton Junction, near Manchester. (*Inventor: Philip Andrew Fisher.*)

The invention relates to the introduction of a volatilisable metal into molten iron or steel; especially into molten iron for the purpose of producing nodular cast iron. According to the invention a device for introducing a volatilisable metal into iron or steel comprises a plunger consisting of or containing a metal suitable for treatment of the iron or steel. The metal has its top and sides sheathed in iron or steel, the sheath being a single pot-shaped member having a rod fixed to it and extending through its end wall. The rod has an anchor device projecting from it inside the sheath. The base of the billet may be coated with refractory. The billet may be pure magnesium or an alloy, e.g. a magnesium alloy containing rare earth metals, or may be rare earth metals alone. A plunger made in accordance with the invention is illustrated and it offers the



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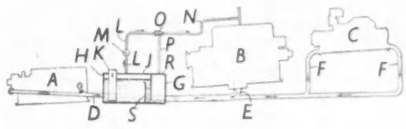
following advantages: 1. The magnesium or other metal tends to volatilise from the open end only whereby the magnesium vapour travels by the longest path through the cast iron, thereby giving the greatest possibility of satisfactory reaction. 2. The exposed area of magnesium, which may be coated with refractory, is minimised, whereby the device is safer in operation than the use of a billet in which the whole surface is exposed. 3. In the event of premature volatilisation any explosion which might result is directed downwards thus minimising the risk of accident. The refractory may be applied for example by coating the exposed magnesium with a synthetic resin and dipping it in sand.—*August* 20, 1958.

MARINE ENGINEERING

799,740. September 8, 1955.—FORCE FEED LUBRICATING SYSTEMS, Yarrow and Co., Ltd., Scotstoun, Glasgow, W.4. (*Inventor: Eric Dott Hobson.*)

The invention relates to force feed lubricating systems particularly for marine propulsion installations. It is an object of the invention to provide means where the outflow of oil from the various low level components of the machinery installation may be efficiently maintained without the necessity of any additional pumping means thereby obviating the attendant disadvantages. As shown in the drawing *A*, *B* and *C* are machinery components such as internal combustion engines, turbines and gearing, &c., of a marine propulsion plant and are adapted to be connected by outflow and return-flow lines for circulating lubricating oil. The outflow lines are indicated by *D*, *E* and *F*, and the return-flow lines to the respective components not shown will be arranged in known manner. The force feed lubricating system for the installation includes a tank unit including a drain tank *G* and a service tank *H* arranged side by side. Both tanks are normally maintained closed and the cover or top *J* of the tank *H* has a return-flow pipe *K* extending therethrough, the pipe having an inlet located adjacent to the base of the tank and being connected with a suitable suction pump for withdrawing oil from the tank and returning it to the various components of the installation. A further pipe *L* is connected with the tank *H* through the top cover, and suction pump *M* is



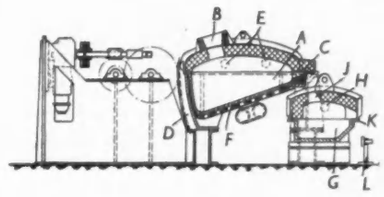
No. 799,740

provided for withdrawing air from the tank so as to maintain it at a predetermined sub-atmospheric pressure. The air withdrawn from the tank is delivered through the pipe *N* to the vent pipe normally fitted to the casing of the components *B* thereby eliminating the tendency for moist air to be drawn into the component casing from the humid atmosphere normally surrounding it. A venturi *O* is interposed between the pipes *L* and *N* and an air pipe *P* is provided, its upper end opening into the venturi and its lower end opening into the drain tank *G*. The drain tank is connected with the service tank by conduit means which as shown include a partition wall *S*, the lower end of the conduit being in connection with the drain tank adjacent to the base thereof and the upper end being disposed at or just below the normal level of liquid in the service tank *H*. Both the drain and service tanks are at a low level in the lubricating system, such that the base of the drain tank is located at a sufficiently low level in relationship to the lowest outflow point of any one of the machinery components that oil will flow into it by gravity with whatever assistance may be afforded by the depression in the tank caused by venturi *O*. In operation oil will flow through the outflows connected with the machinery components into the lower end of the drain tank *G* and, by reason of the difference in pressure in the tanks due to the service tank being at sub-atmospheric pressure and the drain tank at substantially atmospheric pressure, oil will be induced to flow through the conduit *S* into the service tank where it will be discharged at or just below the level of liquid in the tank.—*August* 13, 1958.

PRODUCTION OF SLAG WOOL

799,593. August 2, 1956.—PRODUCING SLAG WOOL FROM BLAST FURNACE SLAG, The Dortmund-Horder Huttenunion Aktiengesellschaft, Rheinischestrasse 173, Dortmund, Germany.

When molten blast furnace slag is blown to form slag wool directly from the tapped material the irregularity of the flow of slag has an unfavourable effect. To obtain satisfactory results, it is necessary to blow continuously a uniform flow of slag. The invention is concerned with the problem of obtaining a uniform flow. As shown diagrammatically in the drawing a tilting vessel *A* has a charging opening *B*



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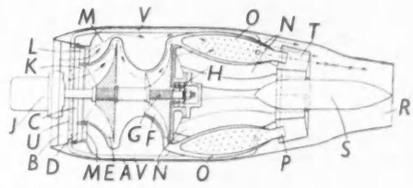
through which the material to be converted into fibres is introduced generally in a molten state. The vessel is adapted to be swung about a pivot axis *C* in the discharge mouth or spout. Tilting is effected by a gearing meshing with a rack *D* on the back of the vessel. The vessel is heated by burners *E*, which act on the surface of the melt contained in the vessel. The wall of the hearth portion of the vessel *A* on which the cover rests, is constructed as a cooling jacket *F*. Owing to the cooling, slag becomes encrusted on the inside of the vessel and acts as a refractory lining. A stationary vessel *G* is heated by burners *H* and has an opening *J* in the cover, through which the stream of molten slag runs in from the vessel *A* at a constant rate. The vessel *G* is provided with one or more openings *K* through which the stream of molten slag to be disintegrated runs to a blowing arrangement *L* at a constant rate.—*August* 13, 1958.

AIRCRAFT ENGINES

800,261. October 10, 1956.—JET PROPULSION ENGINES, George Simpson Ledgerwood, "Nahoon," Ferguson Street, Plumstead, Cape Province, Union of South Africa.

The engine in accordance with the present invention operates on a different principle to engines of the pure ram jet type, in which there is no mechanical compression of the air, or engines of the turbo-jet type. The chief object of the invention is to evolve a jet propulsion engine in which difficulties already met with and their attendant high cost will be avoided. As the drawing shows the jet propulsion engine illustrated includes a shell or casing *A*, which tapers at its forward end to an inwardly tapering frusto conical air inlet opening *B* leading to two concentric air entry openings *C* and *D* through which air passes to the air compressor and turbine respectively. Mounted within the casing is a two-stage centrifugal compressor, the impellers of which are indicated respectively at *E* and *F*, both impellers being mounted on a common shaft *G* mounted in rear bearings *H* and forward bearings associated with the casing *J* which, as is the usual practice, contains the auxiliaries and starter mechanism. The air inlet opening *B* contains fixed guide vanes *K* which direct the air into the first stage of the compressor and guide vanes *L* which direct air into the turbine, the latter consisting of a series of blades *M* which project radially from the first stage compressor and are rigidly associated therewith. Located to the rear of the second stage of the compressor are a series of combustion chambers which include outer and inner casings *N* and *O*, each inner casing *O* terminating in a nozzle *P*. The combustion chambers are arranged around the inner walls of the shell in such a way as to provide a passageway or passageways for the free flow of air over the



No. 800,261

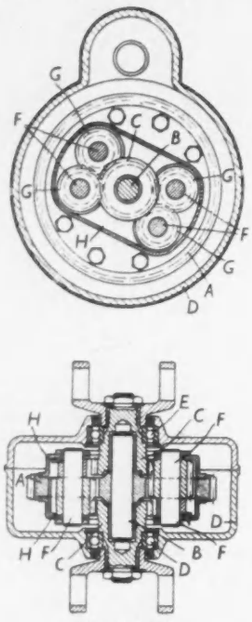
outer casings. The shell converges towards its rear end to provide an exhaust nozzle *R* containing an axially arranged bullet *S* around which is or are arranged concentric ejector cones *T*, into which are discharged the burnt gases from the nozzles *P*, the arrangement being such that air, by the ejector action of the issuing gases from the combustion chambers, will be drawn over the fixed vanes *L* and through the blades *M* of the turbine to drive the latter and its associated two-stage compressor. It will be appreciated that in the drawing the arrangement of the cones *T* and the bullet *S* within the converging walls of the jet efflux nozzle *R* will provide a two-stage ejector which will produce a good induction effect on the air entering the air inlet opening *B*, even when the aircraft is stationary, and when there is no ram effect. The inwardly tapering form of the air inlet opening *B* is such that when the aircraft is moving in relation to the surrounding air, the ram effect will result in an increased weight of air being forced into the two-stage compressor and the turbine associated with the first stage. The flow of air through the turbine and over the combustion chambers and out of the exhaust efflux nozzle is indicated by the arrows shown by full lines, whilst the passage of the air through the two-stage compressor and through the combustion chambers and finally out of the exhaust efflux nozzle is indicated by chain-dotted arrows. It will be appreciated that air entering the turbine will be at an extremely low temperature, and icing conditions may sometimes be encountered, consequently it is proposed to provide the air inlet opening with de-icing equipment which, in the construction shown, takes the form of an annular perforated tubular ring *U* to which hot gases bled from the combustion chambers, pass by way of connecting pipes *V* within the shell or casing. A modified construction is also shown in the Specification.—*August* 20, 1958.

POWER TRANSMISSION

800,230. December 13, 1956.—DIFFERENTIAL GEARING FOR MOTOR VEHICLES, N S U Werke A.G., Neckarsulm/Württemberg, Germany.

Particularly with the smaller sized type of motor vehicles it is desirable to keep the constructional width of the differential gearing as low as possible so as to leave as long as possible the usual types of independent axles in order that changes in camber when the wheels give do not become unpermissibly high. For this, the most suitable have been found to be spur-differentials; but it is difficult to provide adequate bearings for the two driven sun gear wheels while keeping the overall width of the gearing small. The invention shows a way in which to guide the

driven sun wheels in such a manner that good bearing conditions for the toothing are ensured. Under the terms of the invention this is achieved by connecting the two driven sun gear wheels through a central bearing spindle bridging both of them and by having the two driven sun gear wheels directly supported in the differential gear housing in a familiar manner. The drawing shows an axial section through a



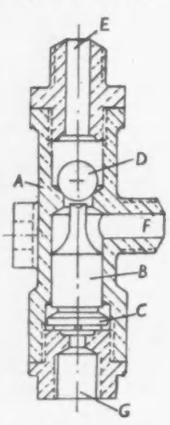
No. 800,230

differential with driving ring gear wheel seated on a central bearing spindle. The differential gearing reproduced in the upper and lower views shows how the driving ring gear wheel *A* is connected to the spindle *B*, which simultaneously rotatably supports driven sun gear wheels *C* internally. The driven sun gear wheels *C* are supported in the housing *D* by bearings *E*. To accommodate the journals *F* on which the planet gears *G* are seated, use is made of end shields *H* of sheet metal, which are connected to the driving wheel *A*. A further type of gearing is also shown in the Specification.—*August* 20, 1958.

AIR COMPRESSORS

799,689. February 10, 1956.—An Automatic Oil Control Valve for Compressors, Thomas Winter Nichols, 23A, Devonshire Road, Bexhill-on-Sea, Sussex.

The invention relates to an automatic oil valve for rotary air compressors through which all the oil for the cooling, sealing or lubrication of the compressor is passed and controlled automatically. The object of the invention is to supply an automatic valve to prevent further flow of oil to the compressor immediately it is stopped, and to reopen for the passage of oil to the compressor on restarting. Referring to the drawing, the invention is shown arranged for working in a vertical position and situated in any convenient position between the oil reservoir and the compressor. The body *A* is fitted with a piston *B* having a head *C* which limits the travel of the piston and, when seated, prevents the leakage of the pressurised air past the piston to mix with the oil passing the oil valve *D*. The oil inlet *E* is connected to the oil receiver, whilst the outlet *F* passes the oil through tubing to the inlet points on the compressor. *G* is the inlet port for the pressurised air that operates the piston and is connected to a suitable position on the delivery port of the compressor or to the space underneath a non-return valve attached to it. As illustrated, the compressor would be stopped and the oil valve *D* would be closed to the passage of any oil to the compressor. On starting up the compressor, its delivery port, being of small capacity, is very quickly filled with air and, this port being connected to inlet *G*, the compressed air acts on the head *C* of the piston and forces it upwards to open the valve *D*, permitting the oil at reservoir pressure to pass from inlet port *E* to outlet port *F* and on to the compressor. On the compressor being stopped, the pressure of the air in the delivery port is reduced to near atmospheric, so that the pressure on the piston head *C* is immediately reduced likewise. The piston *B* is forced downwards by the oil pressure, causing the ball valve *D* to seal and prevent the passage of any more oil to the compressor.—*August* 13, 1958.



No. 799,689

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

VULCANISED RUBBER INSULATION AND SHEATH (INCLUDING POLYCHLOROPRENE) OF ELECTRIC CABLES

No. 2899 : 1958. Price 5s. This specification replaces the clauses on quality of rubber insulation and sheath in the existing standards. The principal change reduces the rubber content of general-purpose insulation from 70–80 per cent to 50–60 per cent by volume. The new compound is similar to Type 2 specified in Defence Specification DEF. 15, used by Government departments. The standard also gives requirements for fire-resisting and ozone-resisting insulation, and for four types of sheath. The specified rubber content of general-purpose sheath is somewhat less than is required by B.S. 7 : 1953. Methods of test, similar to those in B.S. 7, are prescribed for the various types of insulation and sheath. One result of the reduced rubber content of general-purpose insulation, dealt with in the amendments to B.S. 7 and other specifications, is a reduction in the insulation resistance of finished cables. The new values are, however, still considerably greater than those accepted for corresponding PVC-insulated cables and it is understood that the Institution of Electrical Engineers has not found it necessary to modify its regulations for the electrical equipment of buildings on account of the change.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

To-day, Sept. 19.—Annual conference, Harrogate, "Lighting for Safety and Amenity."

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 19.—Stoke and Crewe Branch: Grand Hotel, Hanley, "Electricity Supply and Distribution in North Staffordshire," C. C. Pimble, 7.30 p.m.

Tues., Sept. 23.—Bournemouth Branch: Grand Hotel, Firvale Road, Bournemouth, "Fires and Explosions," S. J. Emerson, 8 p.m.

Wed., Sept. 24.—Brighton, Hove and District Branch: New Imperial Hotel, First Avenue, Hove, "Lighting in Crime Detection," C. H. Edlin, 7.30 p.m. ★ North-West London Branch: Visit to the B.I.C.C., Ltd., Research Laboratory.

Thurs., Sept. 25.—South London Branch: Greyhound Hotel, High Street, Croydon, Film, "Harvest of the Forest," E. E. Webb, 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 24.—London Branch: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Statistics in Radio and Television Manufacture," A. I. Godfrey, 6.30 p.m.

ENGINEERS' GUILD, LTD.

Tues., Sept. 23.—Metropolitan Branch: Caxton Hall, Westminster, London, S.W.1, Eighteenth Annual General Meeting; Discussion on "The Changing Pattern of Leadership," opened by A. R. Cooper, 6 p.m.

Thurs., Sept. 25.—Grosvenor Hotel, Victoria Station, London, S.W.1, Extraordinary Meeting, 5.45 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Sept. 23.—South Wales Branch: South Wales Engineers' Institute, Park Place, Cardiff, Films on "Lubrication Methods," 7.30 p.m.

Thurs., Sept. 25.—Sheffield and District Branch: Grand Hotel, Sheffield, "Hydraulics," F. H. Towler, 7.30 p.m.

Fri., Sept. 26.—Birmingham Branch: Imperial Hotel, Temple Street, Birmingham, "Planned Maintenance," A. F. R. Stedman, 7.30 p.m.

Mon., Sept. 29.—West and East Yorkshire Branch: Fuel Department Lecture Theatre, New Building, The University, Leeds, "Mechanical Plant and Railway Engineering," A. C. Layhe, 7.30 p.m.

INDUSTRIAL WELFARE SOCIETY

Wed., Sept. 24.—Hotel Rembrandt, Thurloe Place, London, S.W.7, "New Thinking" Luncheon: "The Principles behind Industrial Relations in America," Judge Boyd Leedom, 12.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Sept. 22.—Bath and Bristol Centre: South Western Electricity Board, Old Bridge, Bath, "Horticultural Lighting," A. W. Gray, 7 p.m.

Fri., Sept. 26.—Birmingham Centre: Regent House, St. Phillips' Place, Colmore Row, Birmingham, Chairman's Address, "Modern Lighting and Production," L. E. Gibbs, 6 p.m.

Mon., Sept. 29.—Leicester Centre: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, Chairman's Induction, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Sept. 24.—London Branch: Constitutional Club, Northumberland Avenue, London, W.C.2, Presidential Address, D. E. B. Barnard, 7.30 p.m.

Tues., Sept. 30.—Slough Section: Lecture Theatre, High Duty Alloys, Ltd., Slough, Brains Trust, "Precision-Casting Techniques," 7.30 p.m.

INSTITUTE OF WELDING

Wed., Sept. 24.—54, Princes Gate, Exhibition Road, London, S.W.7, "Welding in Low Temperatures," D. Pratt, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Sept. 20.—North-Eastern Graduate and Student Section: Visit to Edinburgh, 8 a.m.

INSTITUTION OF ENGINEERING DESIGNERS

Tues., Sept. 23.—Yorkshire Branch: Midland Hotel, Bradford, "Fan Cooled Worm Gear Reduction Units," J. W. Peake, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues. to Thurs., Sept. 23 *to* 25.—1, Birdcage Walk, Westminster, London, S.W.1, International Conference on Gearing, 10 a.m.

Tues., Sept. 23.—Birmingham A.D. Centre: James Watt Memorial Institute, Birmingham, Informal Discussion, "Will the Coming of Motorways Require Redesign of Motor Vehicles?" 6.30 p.m.

Wed., Sept. 24.—East Midlands Branch: Room C4, Engineering Building, The University, Nottingham, Chairman's Address, 7.30 p.m. ★ Yorkshire Branch: Visit to Newton Chambers and Co., Ltd., Thorncliffe Works, Chapeltown, Sheffield, 2.30 p.m.; Royal Victoria Hotel, Sheffield, "Recent Developments in the Manufacture of Castings," J. L. Rice, R. W. Ruddle and P. A. Russell, 6.30 p.m. ★ North-Western Graduates' Section: Engineers' Club, Albert Square, Manchester, Chairman's Address, 7 p.m. ★ Southern Graduates' Section: Technical College, Guildford, "Experiences of a Lubrication Engineer," J. Ariey, 7 p.m.

Thurs., Sept. 25.—East Midlands Graduates' Section: Technical College, Lincoln, "Vibrations of Various Components in Gas Turbines," J. M. Radford, 7.15 p.m. ★ Southern Graduates' Section: Technical College, Portsmouth, Film Show, 7 p.m.

Fri., Sept. 26.—North-Western Branch: Barrow-in-Furness Panel: Lecture Theatre, College for Further Education, Abbey Road, Barrow-in-Furness, "Application of Nuclear Power to Marine Propulsion," J. E. Richards, 7.30 p.m.

Sat., Sept. 27.—Scottish Branch: Visit to Calder Hall Atomic Power Station. ★ Southern Branch: Visit to the Esso Research Laboratories, near Abingdon, 10.15 a.m.

Mon., Sept. 29.—Southern Graduates' Section: Cockcroft Hall, Harwell, "Gas Lubricated Bearings and their Applications," D. Pantall, 3.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Tues. and Wed., Sept. 23 *and* 24.—Federation of British Industries, 21, Tothill Street, Westminster, London, S.W.1, Symposium on "The Future of Non-Ferrous Mining in Great Britain and Ireland," 10 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Sept. 20.—Luton Graduate Section: Visit to the British Tabulating Machine Company, Ltd., Letchworth, 10 a.m.

Wed., Sept. 24.—Midlands Region, Shrewsbury Section: Technical College, Shrewsbury, Film, "Copy Turning," 7.30 p.m.

PHYSICAL SOCIETY

Fri. and Sat., Sept. 19 *and* 20.—University College, Swansea Autumn Conference on "Gas Discharges."

Wed. and Thurs., Sept. 24 *and* 25.—Durham Colleges, The University, Durham, Conference on "Cosmic Rays."

PLASTICS INSTITUTE

To-day, Sept. 19.—Midlands Section: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Peoples and Places in the U.S.S.R.," G. Tolley, 6.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Sept. 23.—Midland Section: Visit to Midland Tar Distillers, Ltd., Four Ashes, 7 p.m.

Wed., Sept. 24.—Chester Section: Lecture Theatre, Grosvenor Museum, Grosvenor Street, Chester, Presidential Address, 7 p.m.

Tues., Sept. 30.—London Section: Manson House, Portland Place, London, W.1, "Frequency Response Analysis using Describing Function Method," J. C. West, 5.30 p.m.

TELEVISION SOCIETY

To-day, Sept. 19.—Cinematograph Exhibitors' Association Theatre, Third Floor, 164, Shaftesbury Avenue, London, W.C.2, "Experimental Colour Receiver: Setting Up and Adjustment," E. Ribchester, 7 p.m.

Advanced Engineering Courses

Communication Engineering Economics. Department of Electrical Engineering, South East London Technical College, Lewisham Way, London, S.E.4. A course of twenty-six lectures, commencing Monday, October 6, 6.45 p.m., of particular interest to Post Office engineers and traffic officers and to staff of firms engaged in the preparation of tenders for the supply and installation of communication equipment for export. Application should be made to the Head of the Electrical Engineering Department. Fee £1 12s. 6d.

Electronic Computing Systems. Part I: The Construction and Operation of Electric Digital Computing Systems Designed for Commercial Purposes. Department of Mathematics, Sir John Cass College, Jewry Street, Aldgate, London, E.C.3.—A course of nine lectures, commencing Wednesday, October 8, 6.30 p.m., intended for executives and others interested in the commercial applications of electronic computers. Application should be made to the Secretary of the College. Fee, for those residing in the County of London, £1.

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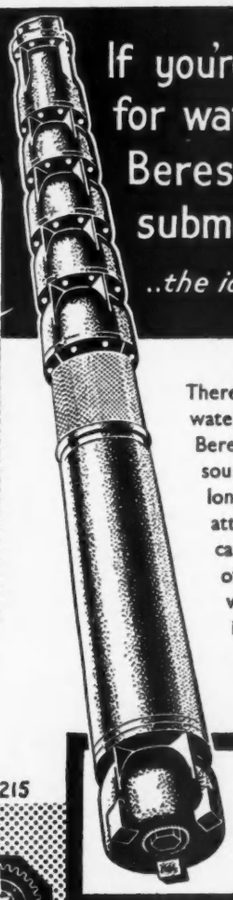

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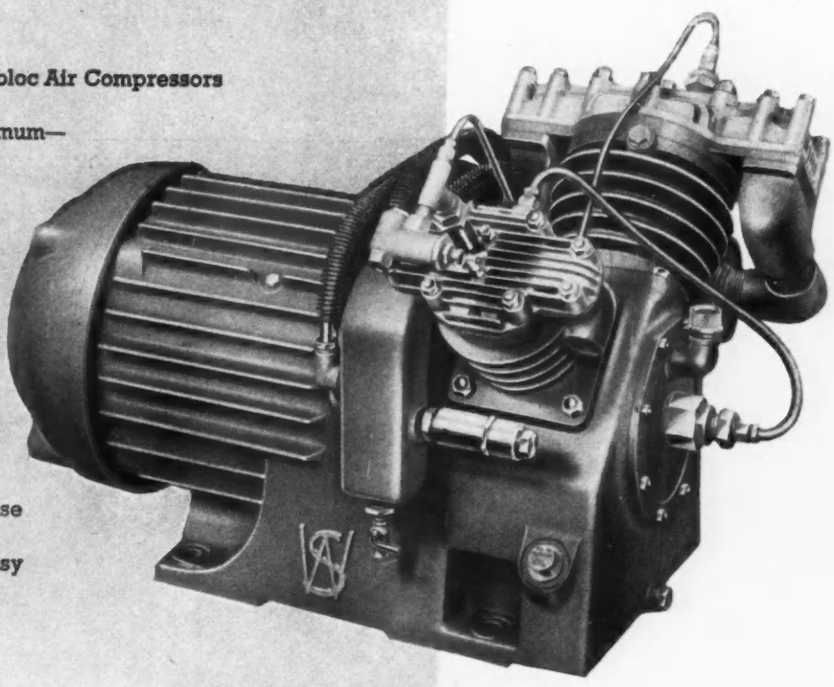

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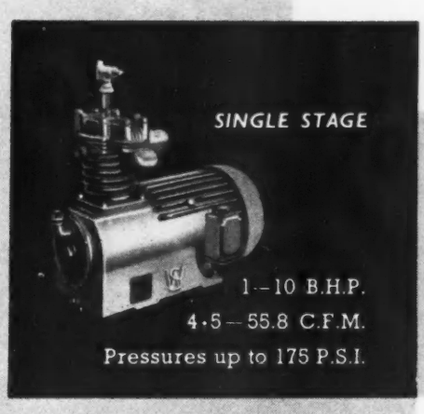

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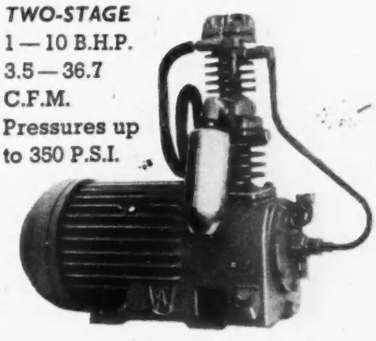

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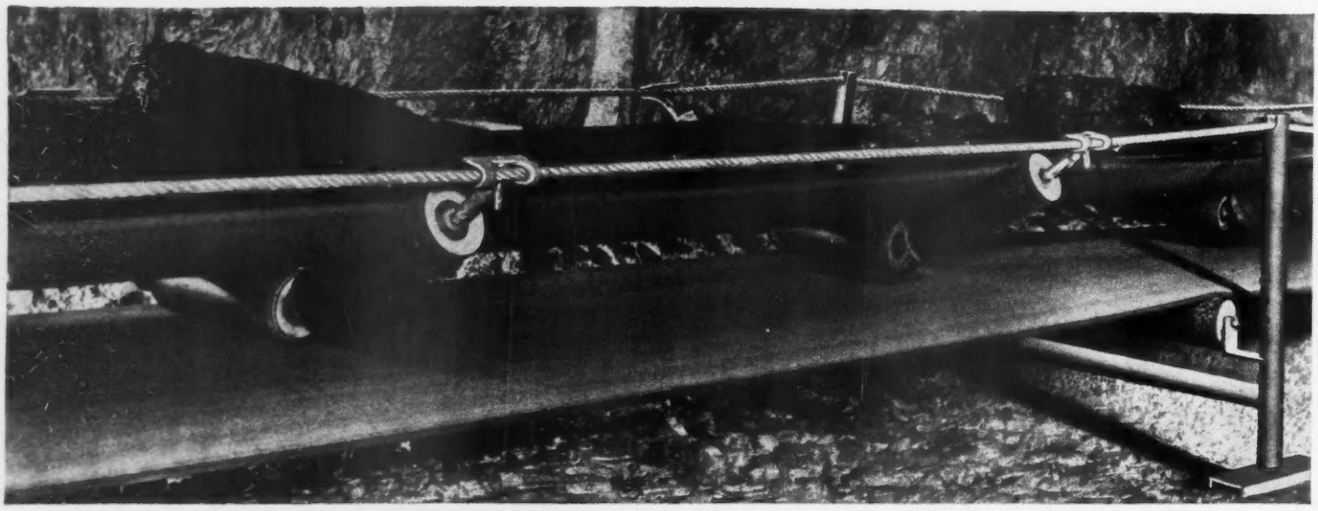
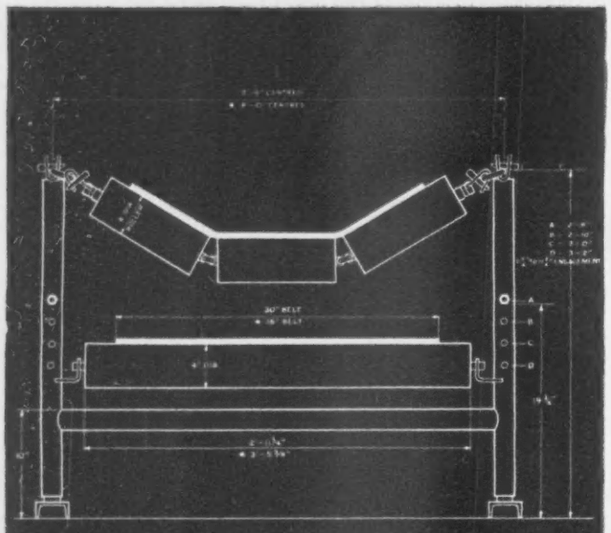
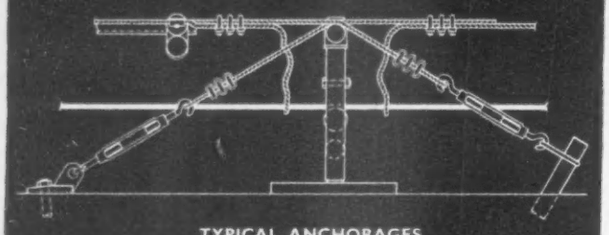




INTERMEDIATE STAND
(Adjustable for height)



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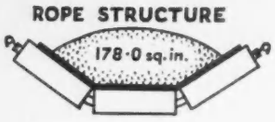

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The longitudinal members of this conveyor structure consist of $\frac{5}{8}$" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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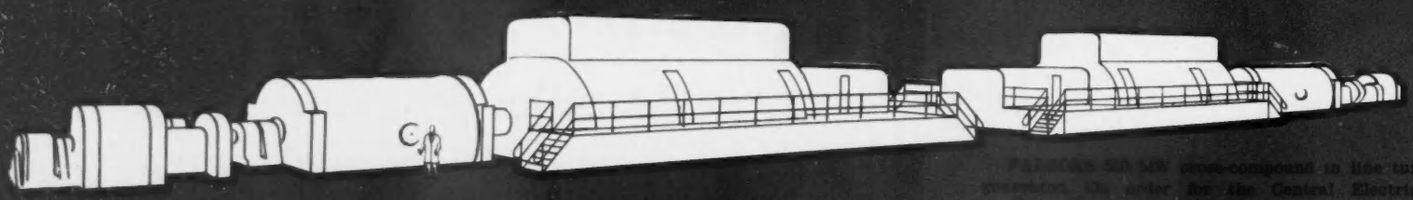
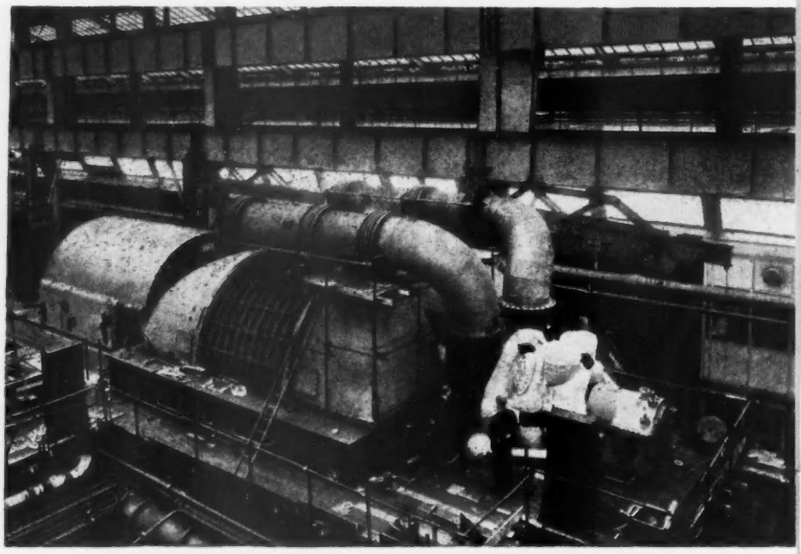


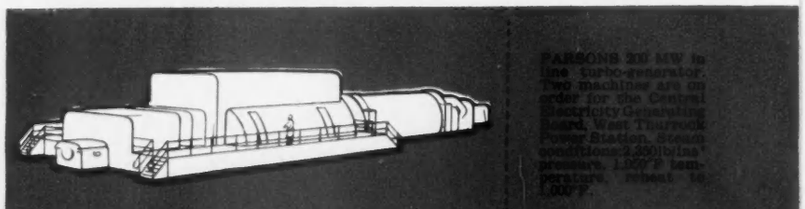
PARSONS 525 MW cross-compound in line turbo-generator. On order for the Central Electricity Generating Board projected power station at Thorpe Marsh. Steam conditions: 2,300 lbs/ins² pressure, 1,050°F temperature, reheat to 1,050°F.

Increasing power output

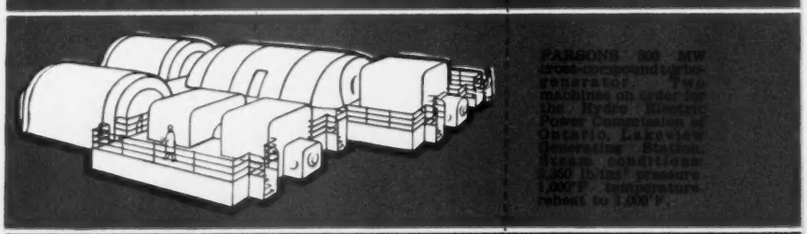
A significant development in the design of steam turbo-generators for power stations is the increase in the power output of individual machines. This is evident in the range of large turbo-generators now under construction at Heaton Works.



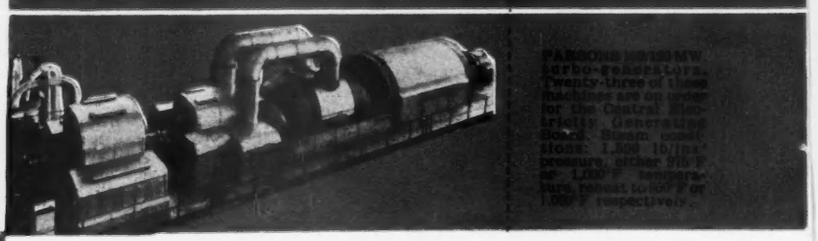
PARSONS 200 MW cross-compound turbo-generator (View of low pressure line only). Four of these machines are under construction for the Hydro Electric Power Commission of Ontario, Richard L. Hearn Generating Station. Steam conditions: 1,800 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.



PARSONS 200 MW in line turbo-generator. Two machines are on order for the Central Electricity Generating Board, West Thurrock Power Station. Steam conditions: 2,350 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.



PARSONS 300 MW cross-compound turbo-generator. Two machines on order for the Hydro Electric Power Commission of Ontario, Lakeview Generating Station. Steam conditions: 1,450 lb/ins² pressure, 1,000°F temperature, reheat to 1,000°F.



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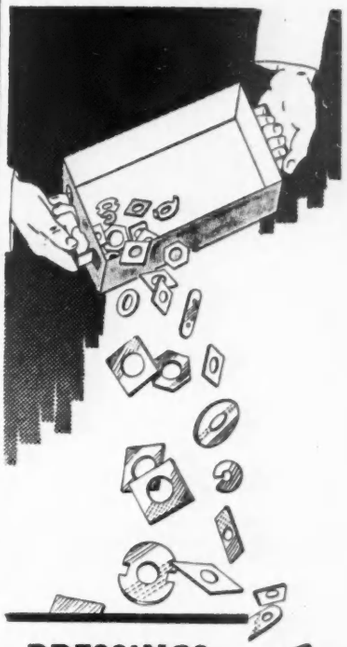

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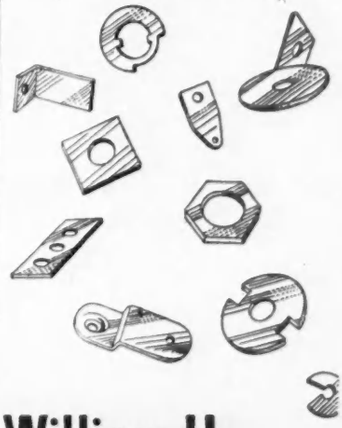

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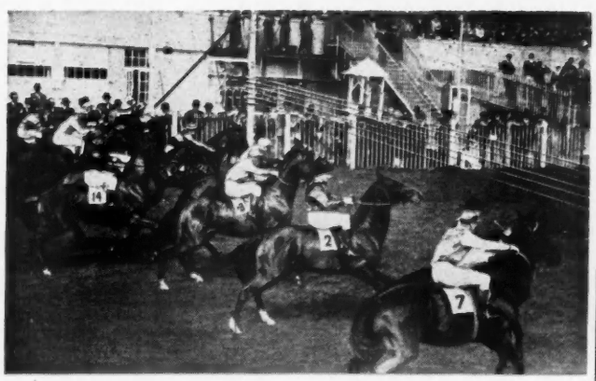

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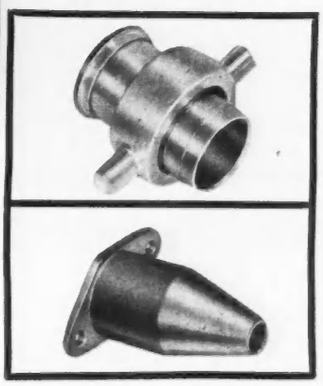

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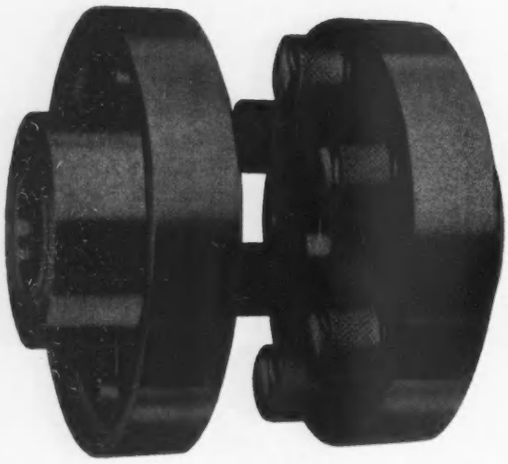

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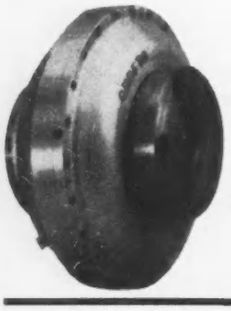

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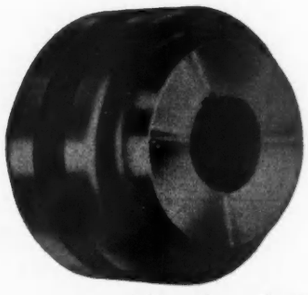

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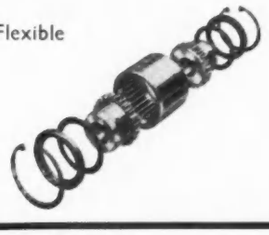

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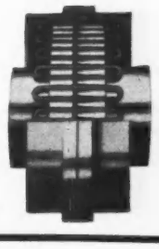

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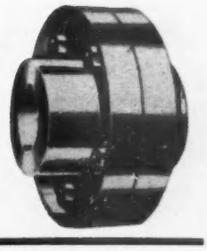

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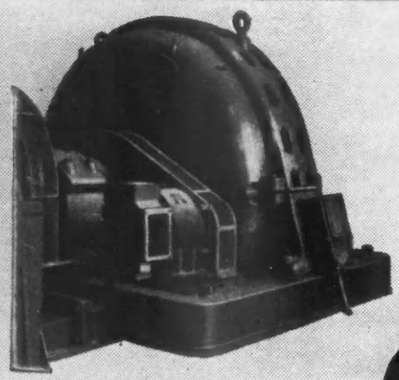

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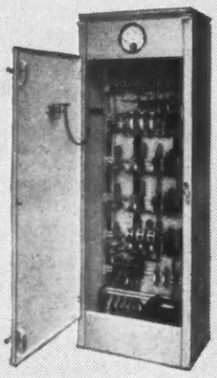

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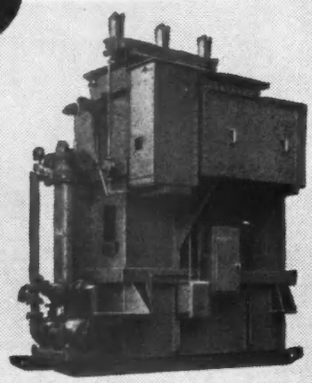

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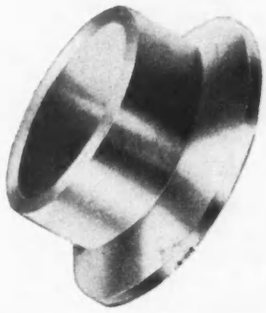

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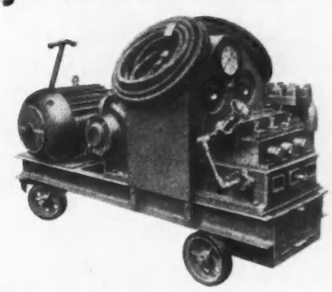

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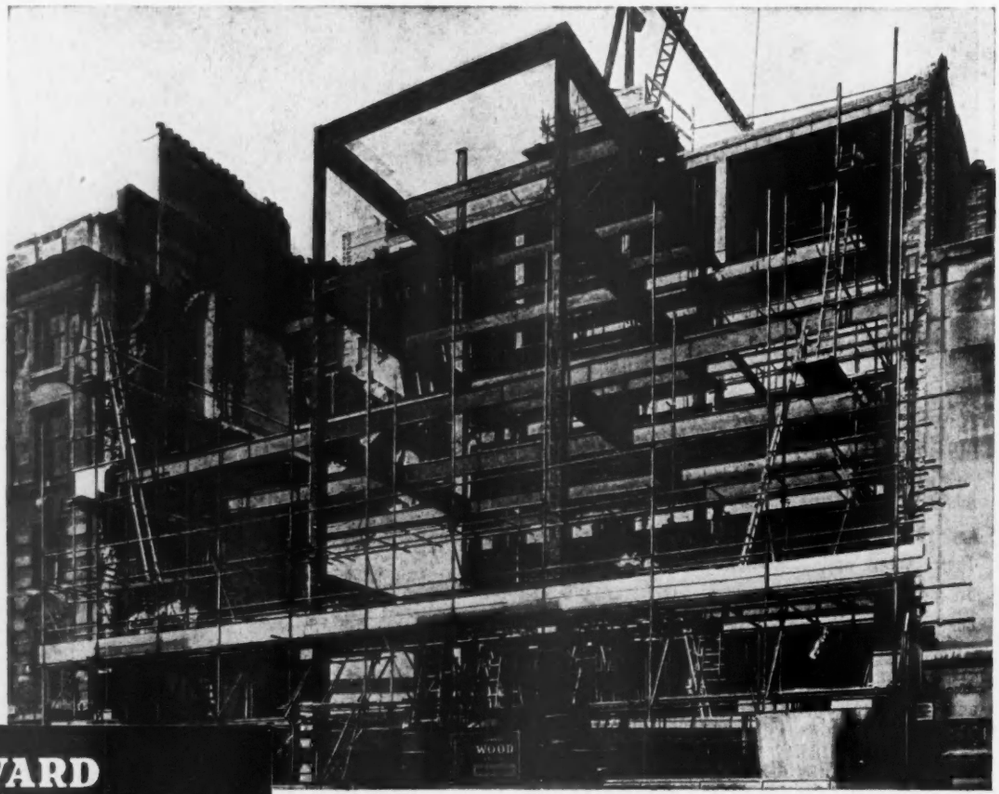

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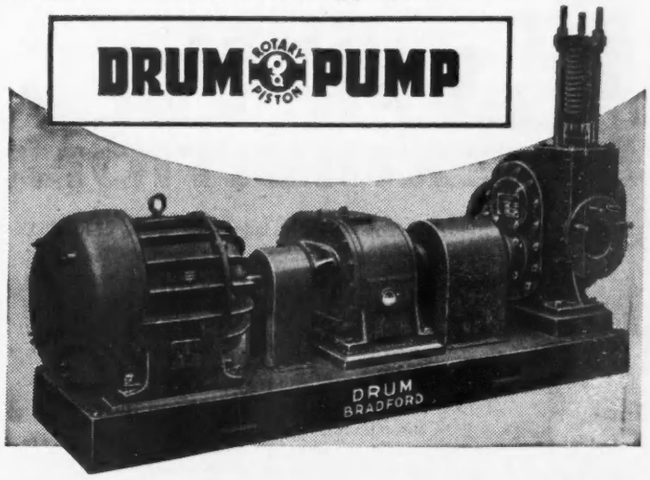

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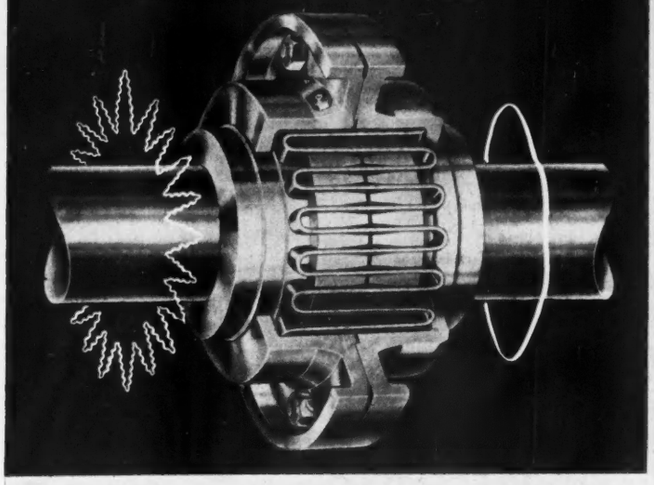

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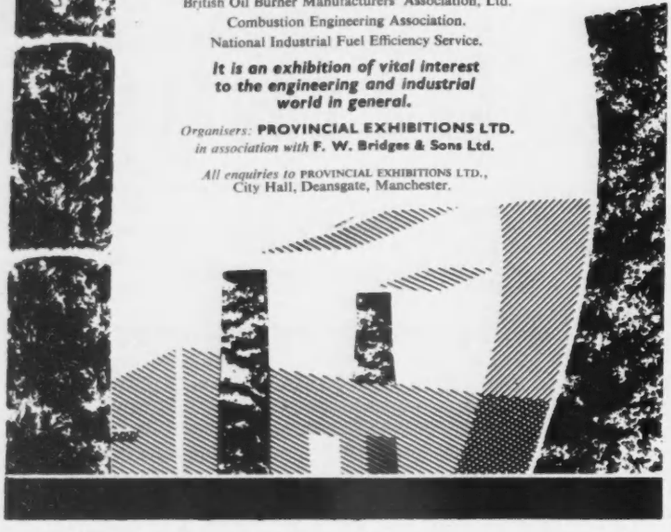

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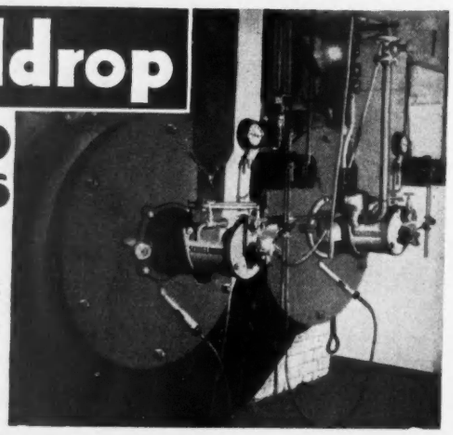

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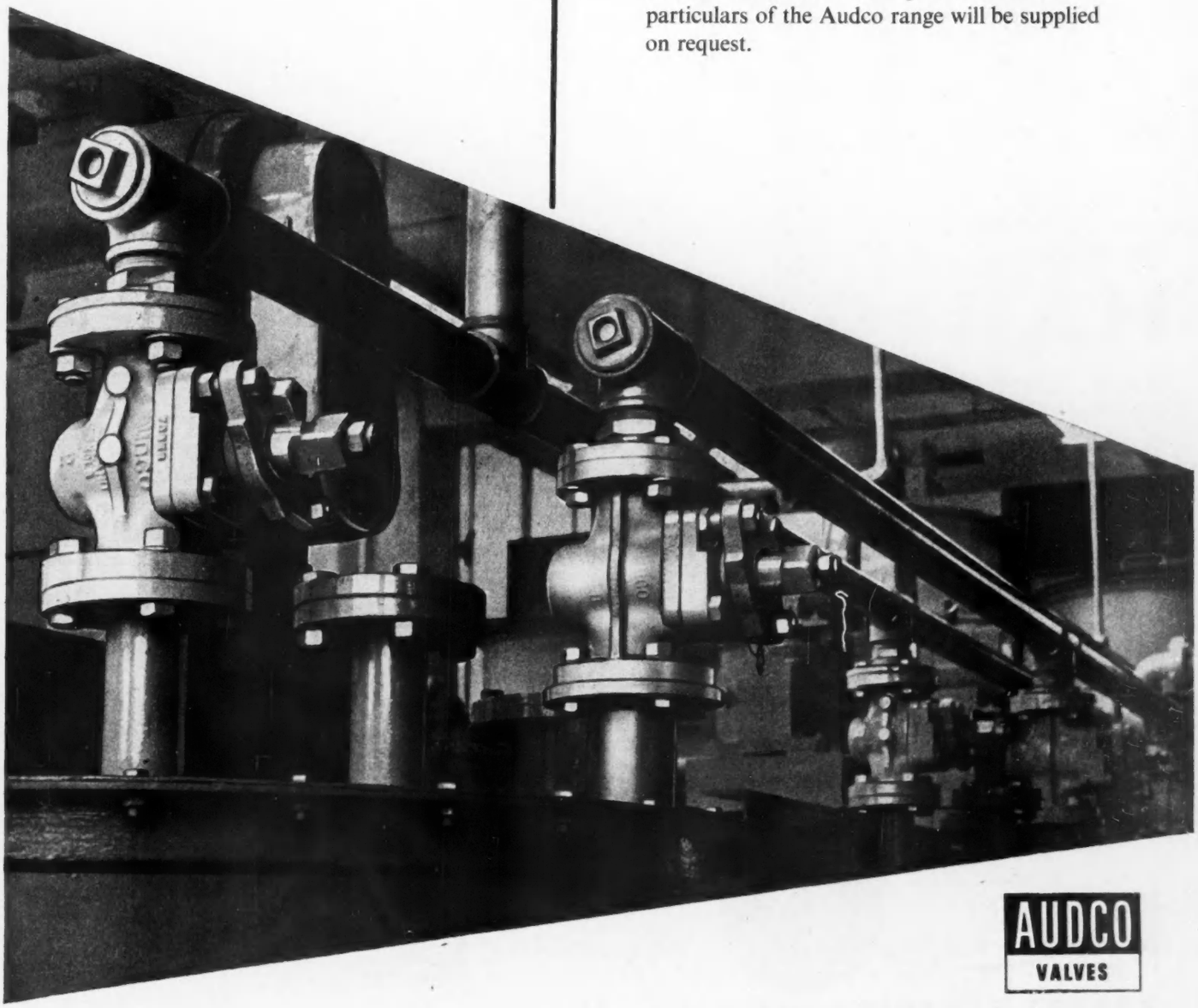

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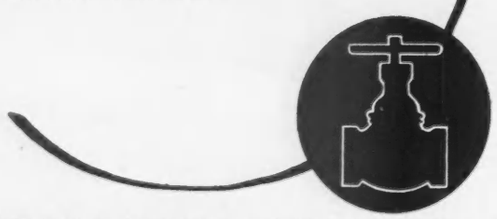

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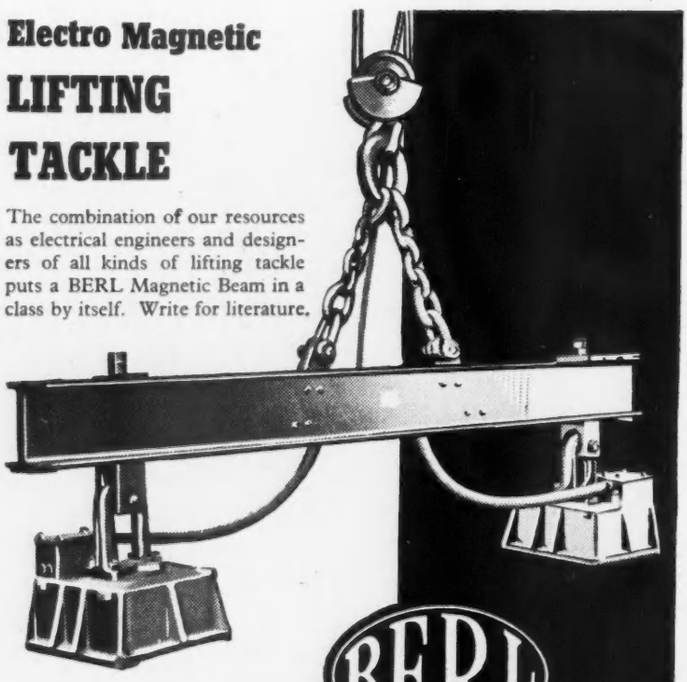

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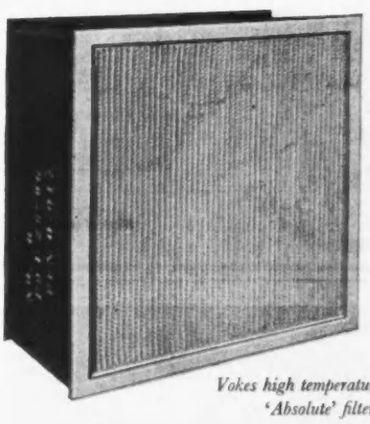

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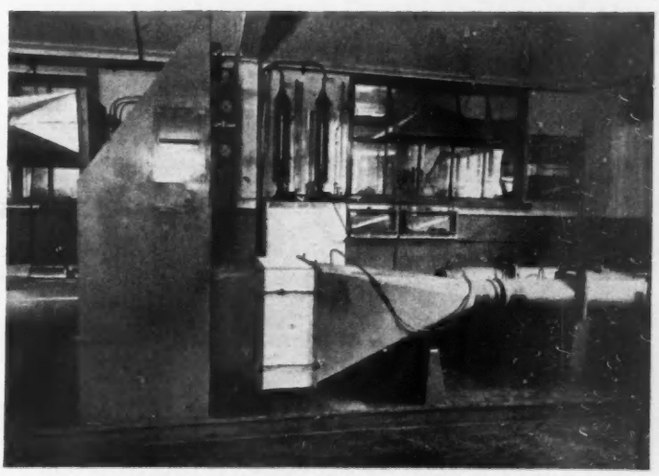

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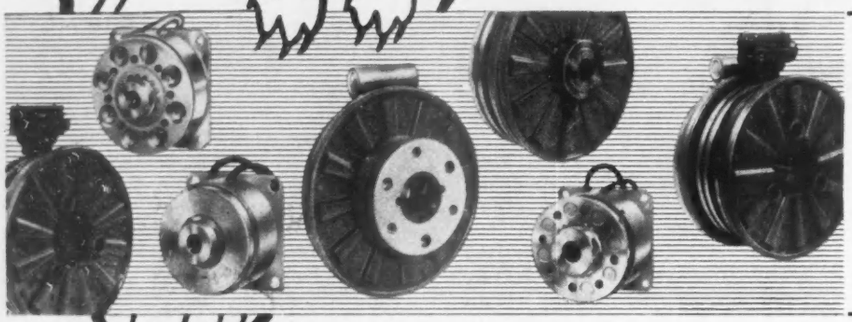

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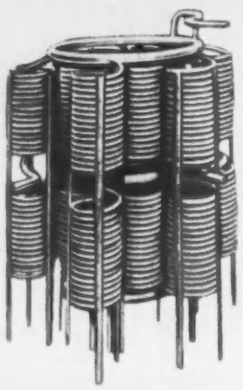

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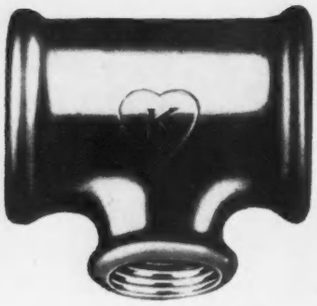

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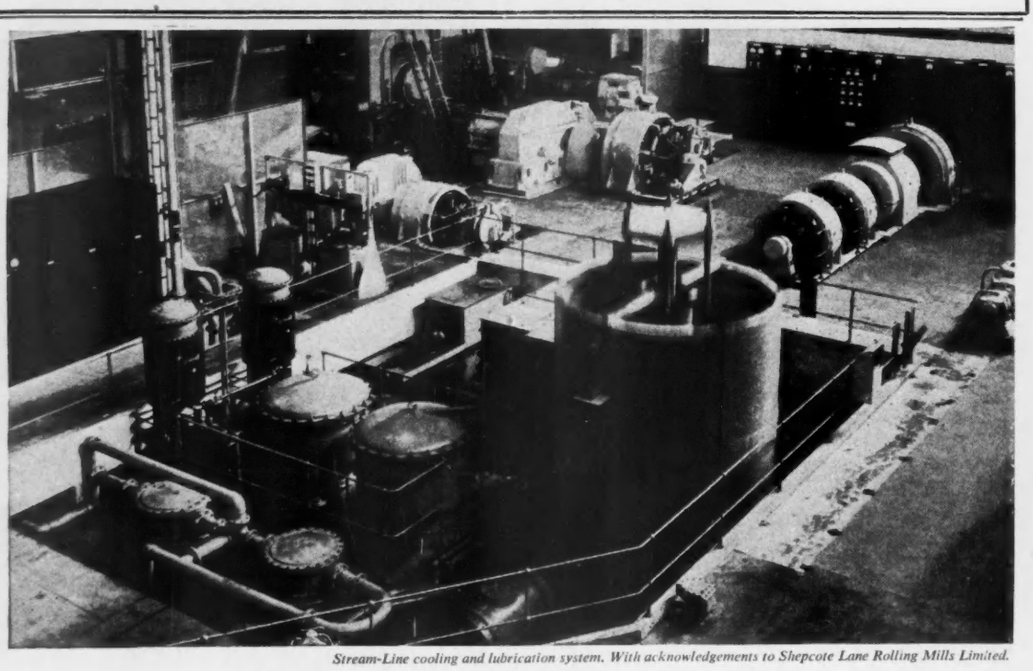

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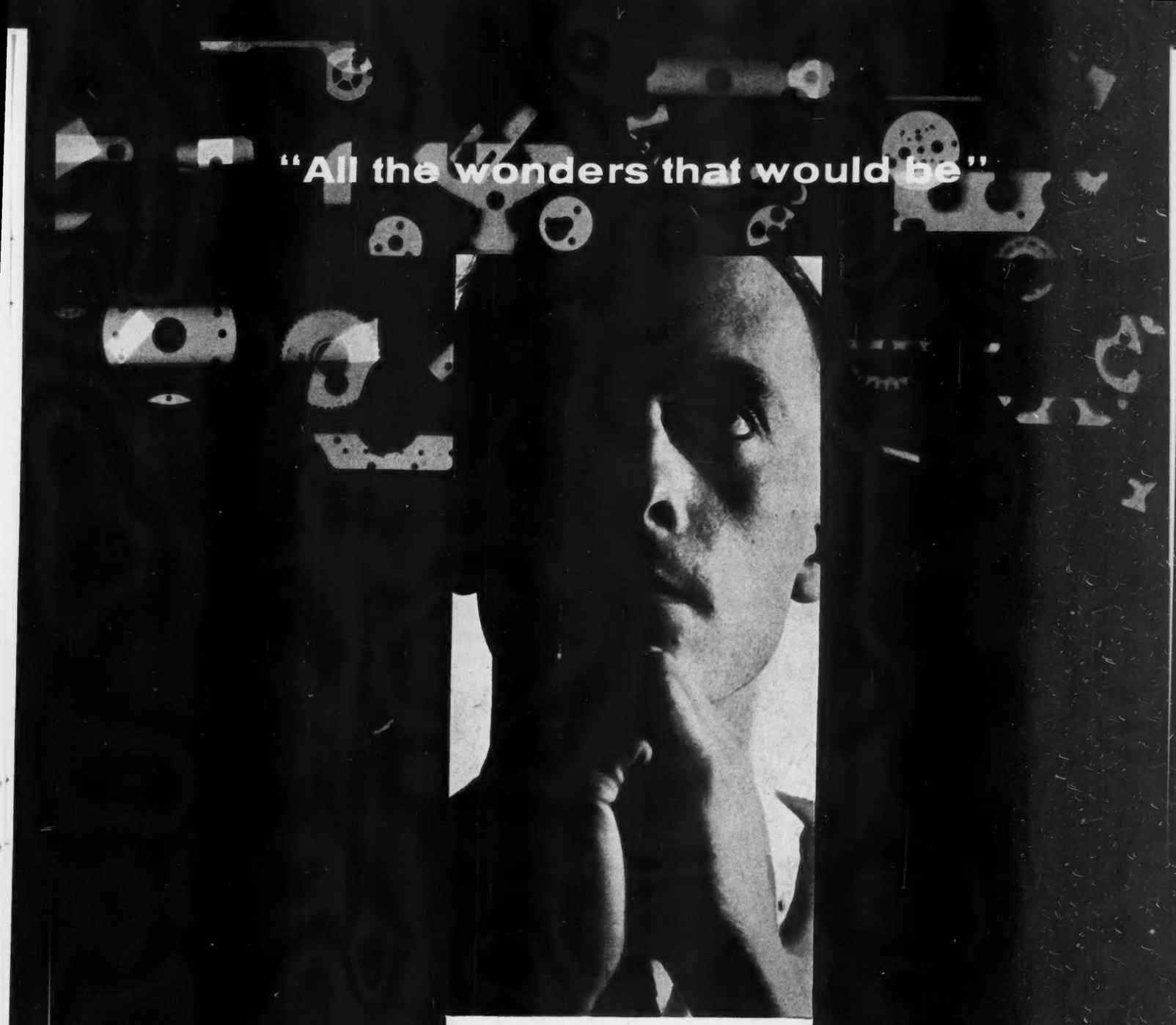

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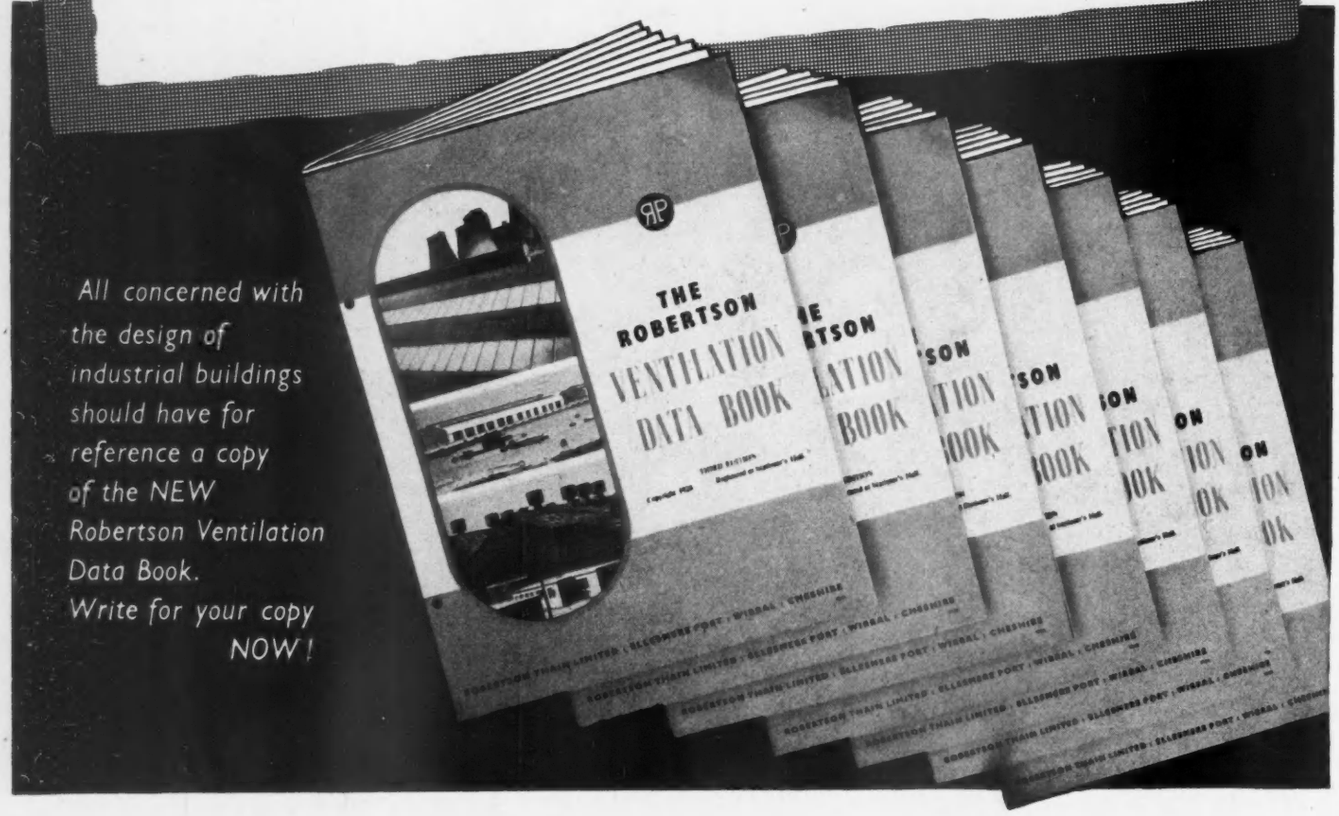

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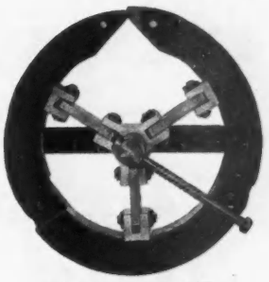

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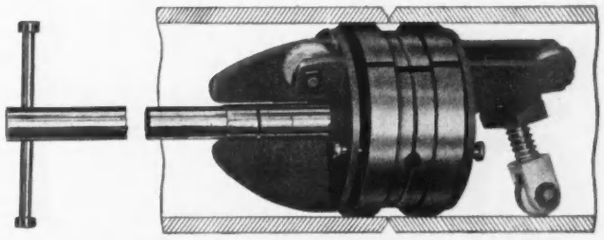
FOR THE ACCURATE ALIGNMENT OF PIPES FROM THE BORE



The aligner, in the contracted position, is propelled along the pipe internally in a position between the pipes to be butt welded. By operating a tommy bar on the end of extension tubes the aligner is expanded and presses out the pipe walls to their truly round form. Pressure holds the two pipes together in perfect alignment whilst the weld is laid—the aligner is then contracted and rolled along the pipe for the next weld.

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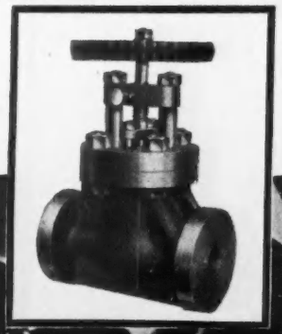

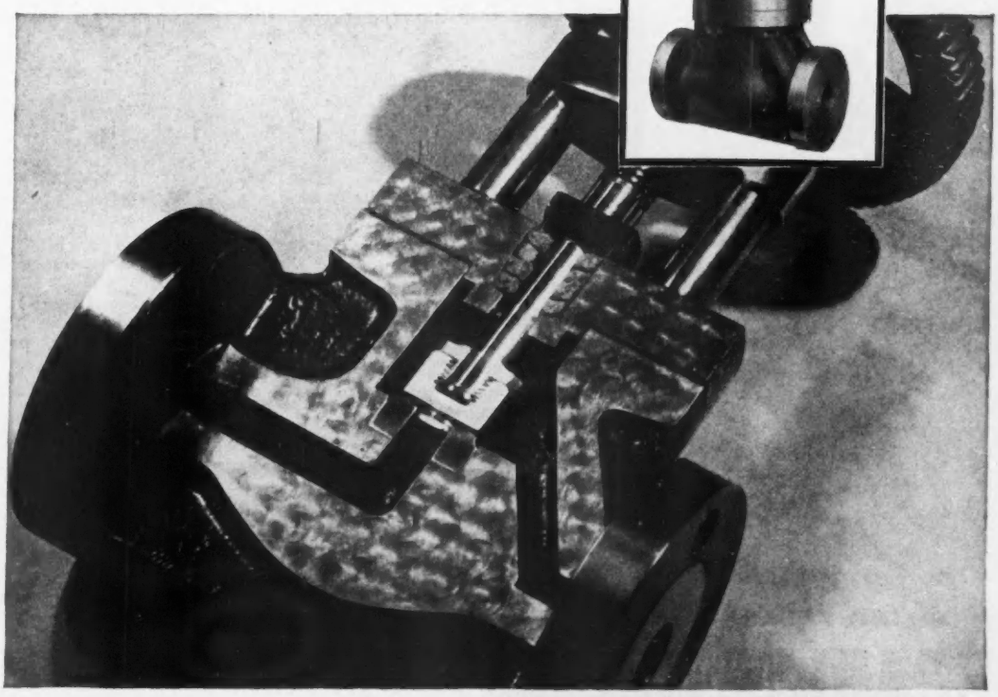

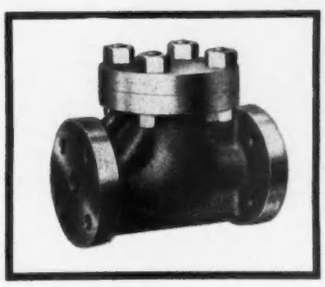

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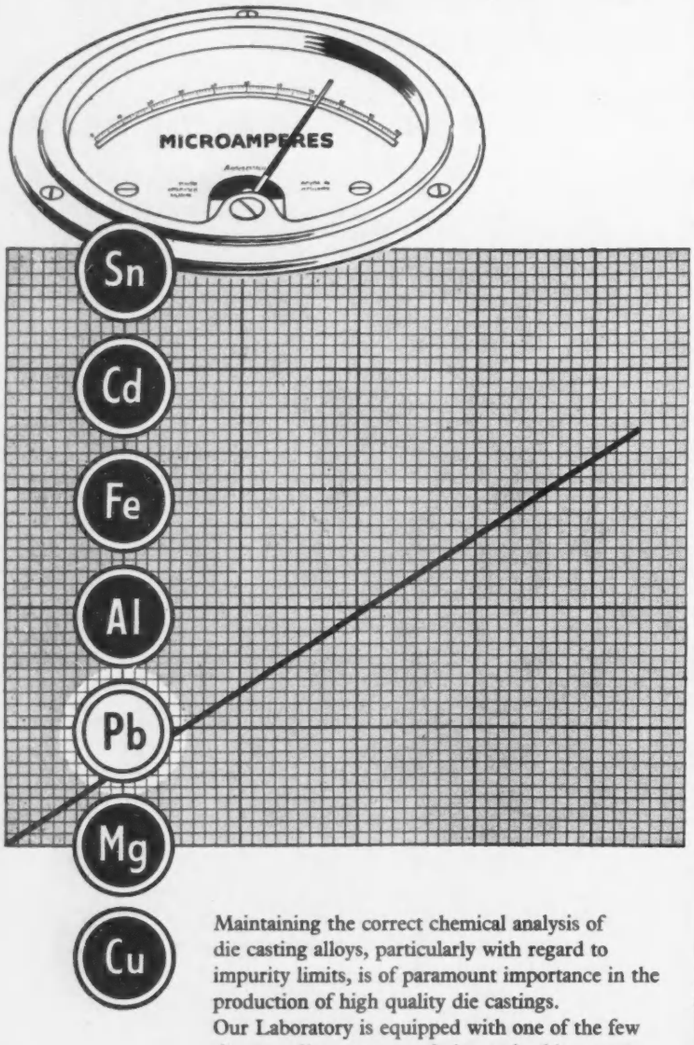

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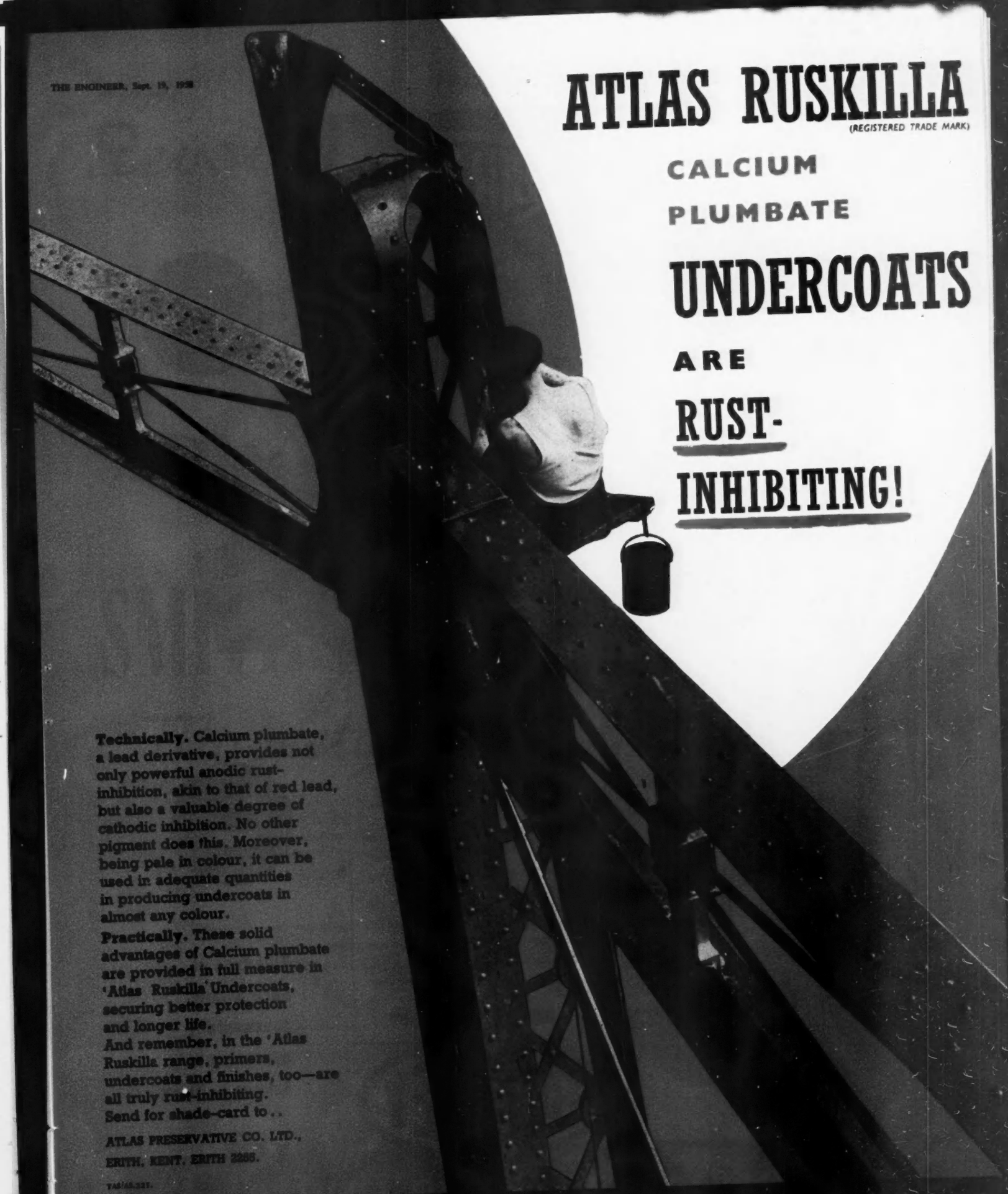

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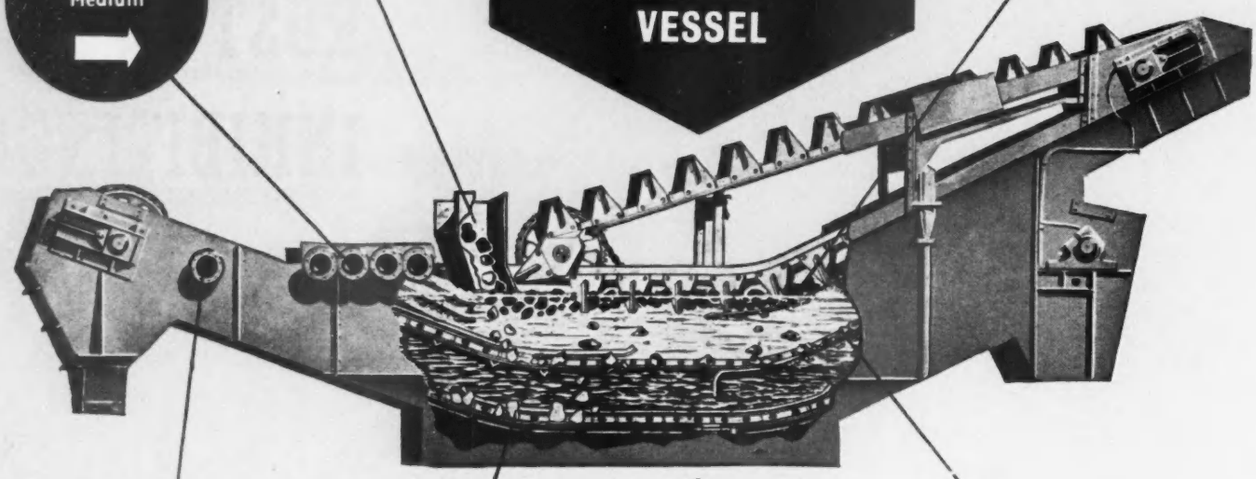

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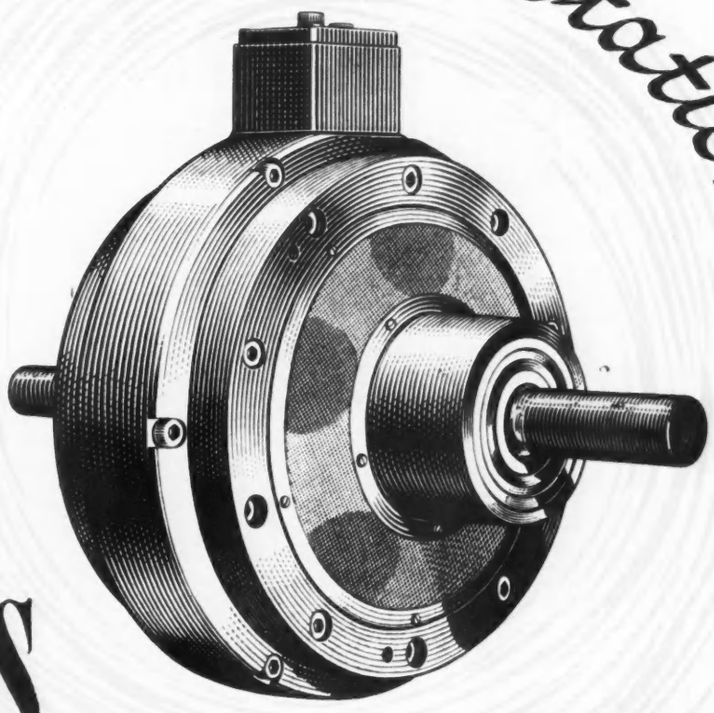

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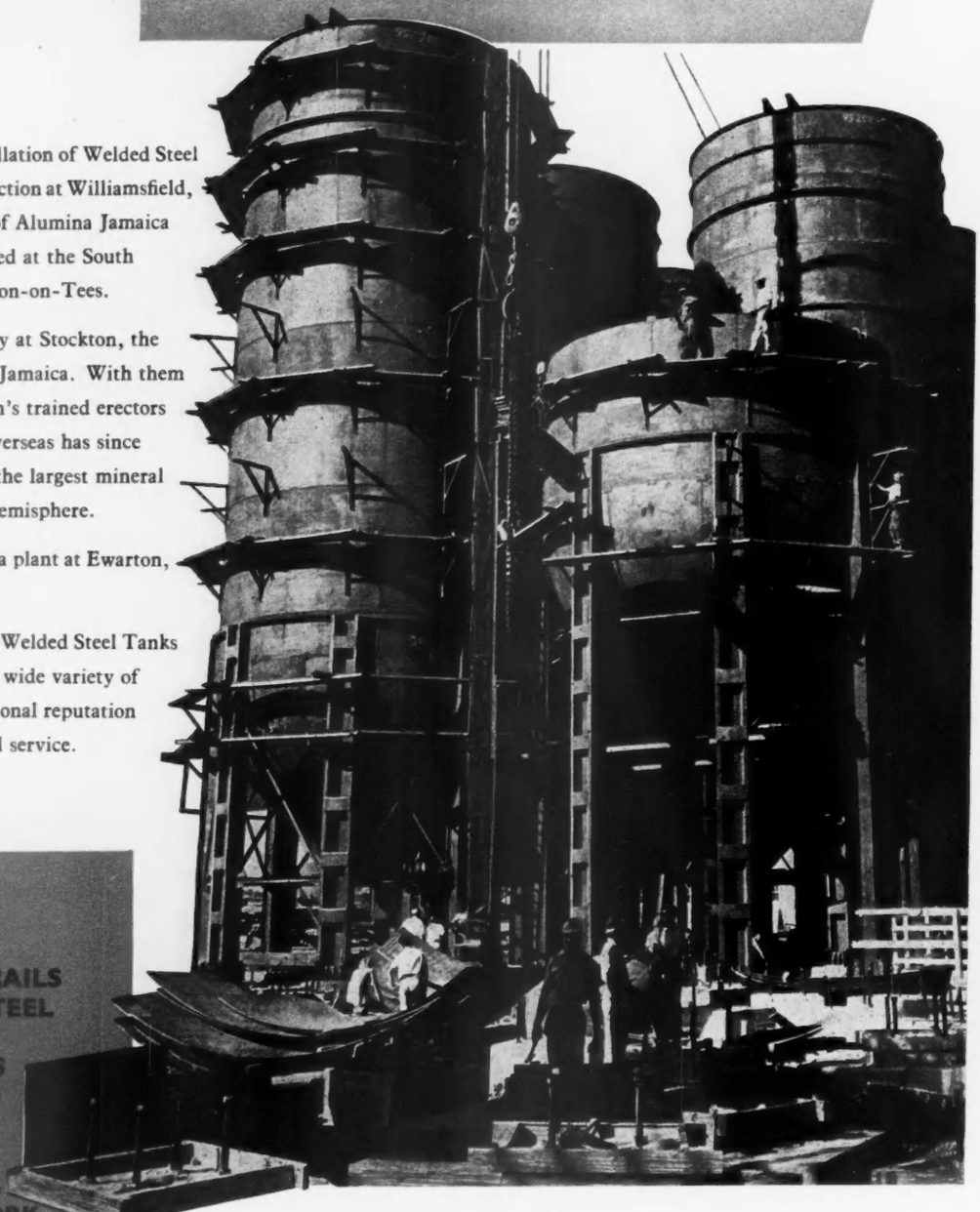

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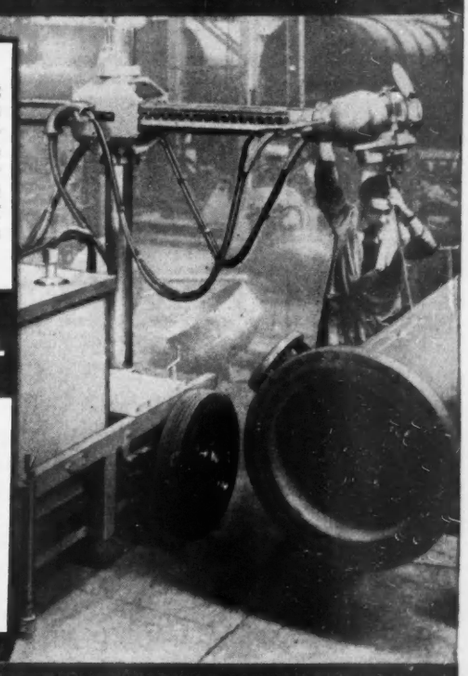
(Left) — Attached to the Extending Suspension Mounting running on overhead rails, the Marconi Tubehead can be manipulated with ease over the largest components as, for instance, the one-piece cast steel bogie shown. (Photo by courtesy of English Steel Castings Corporation Ltd.)

250 k V CONSTANT POTENTIAL X-RAY EQUIPMENT

(Right)—The Self-propelled Mobile Mounting can be manoeuvred about the shop floor, enabling large components to be inspected without disturbing the flow of production. (Photo by courtesy of W. J. Fraser & Co. Ltd., Chemical Engineers)



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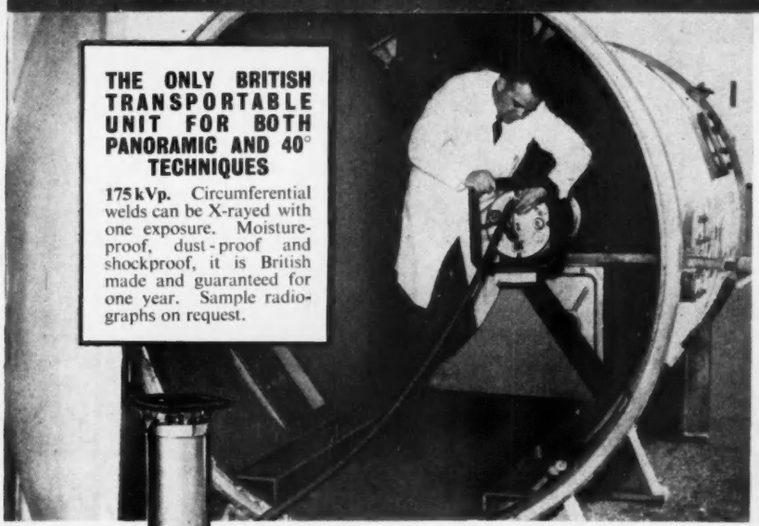

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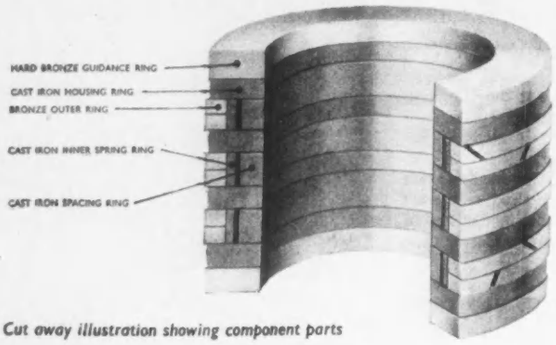

Cut away illustration showing component parts

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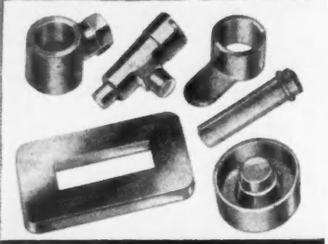

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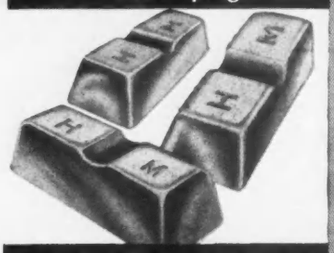

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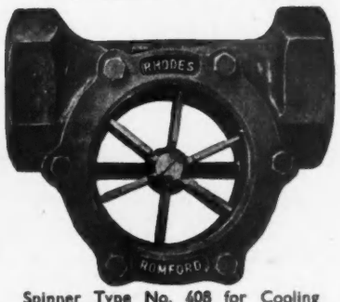

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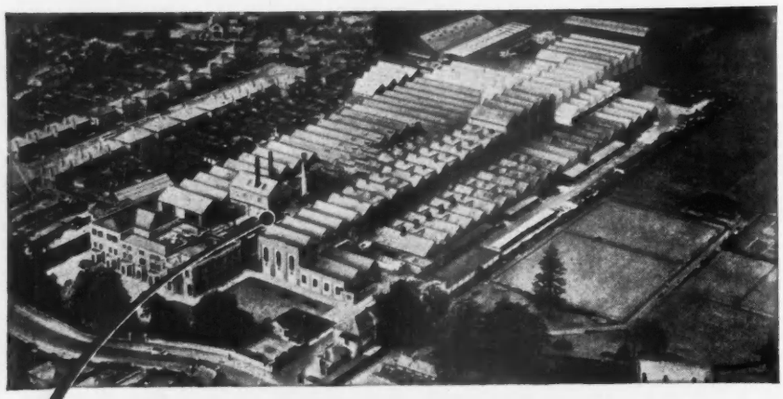

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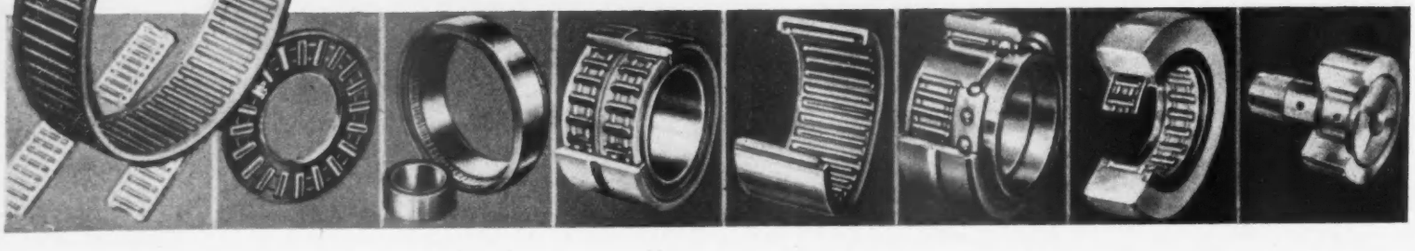

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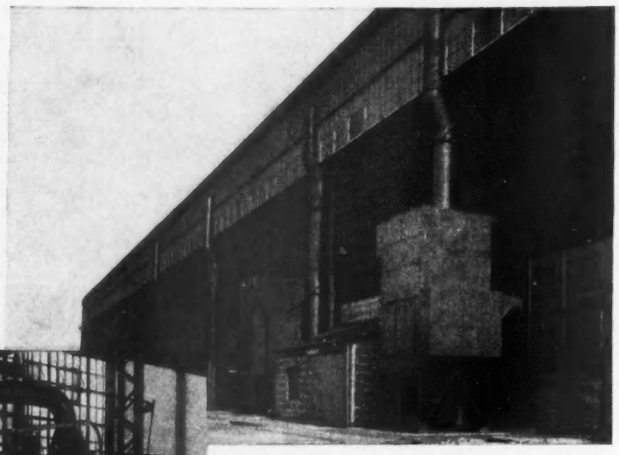

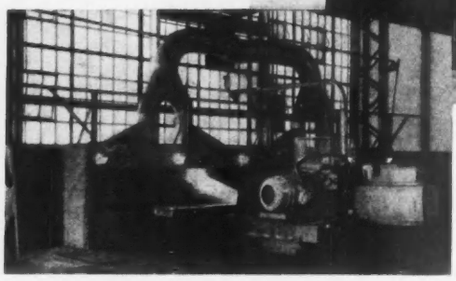

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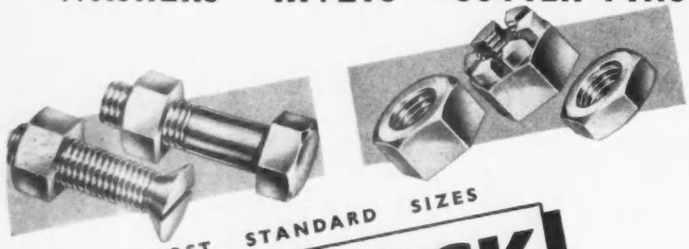

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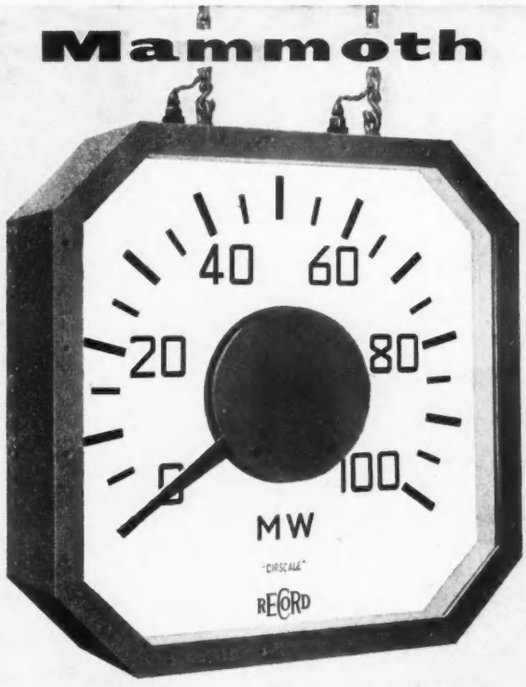

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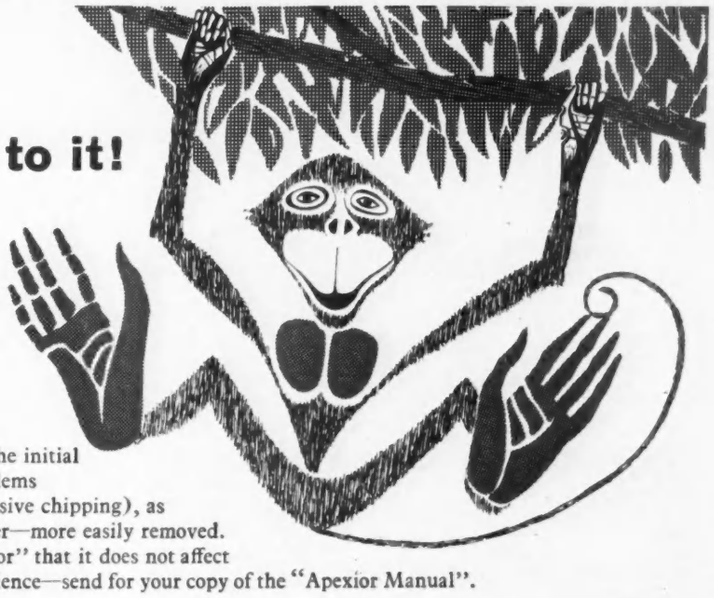

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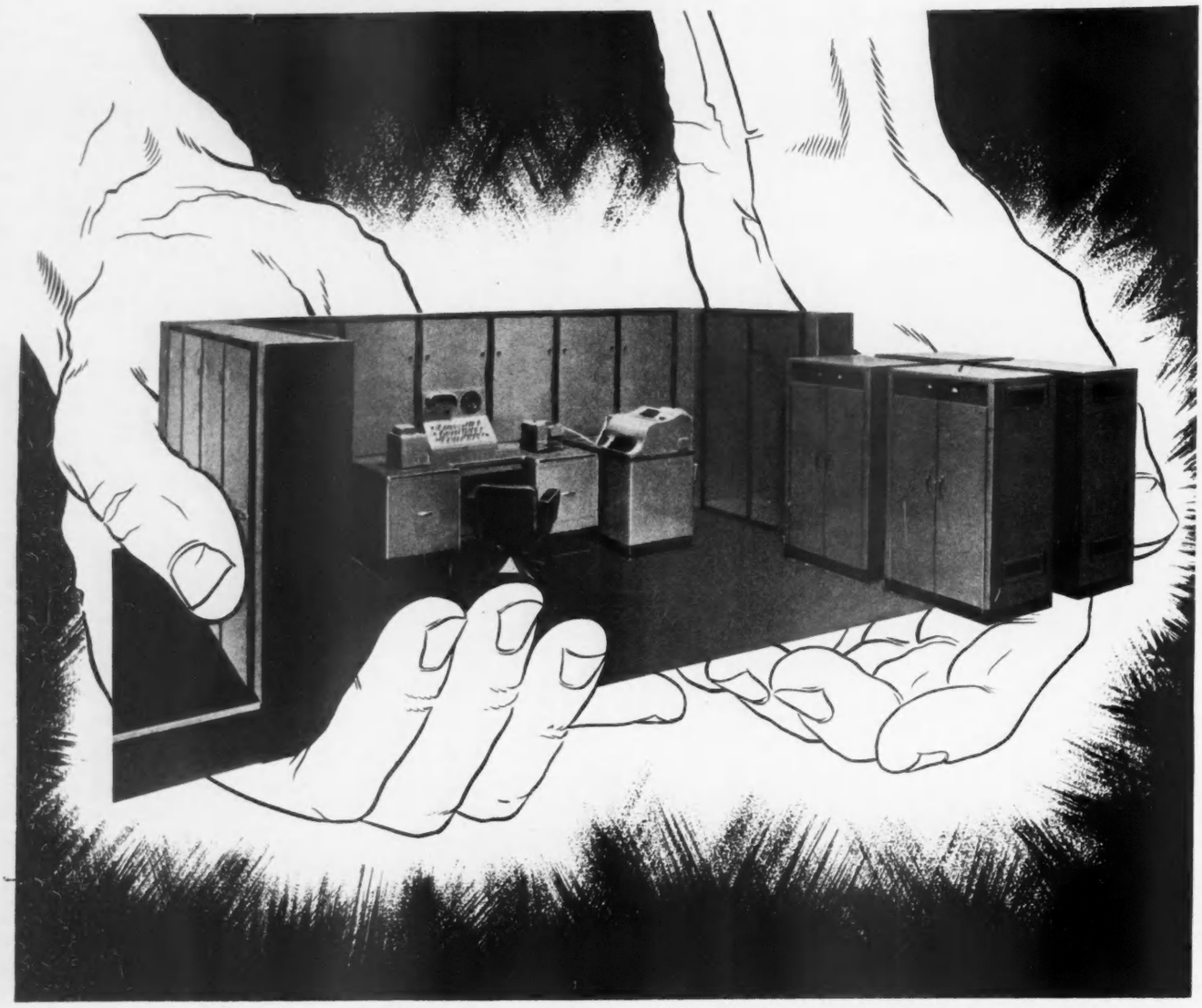

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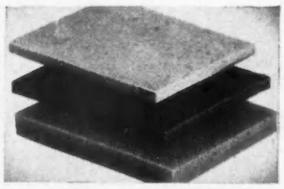

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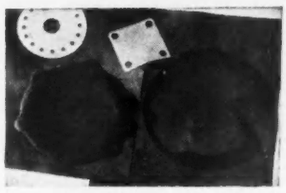

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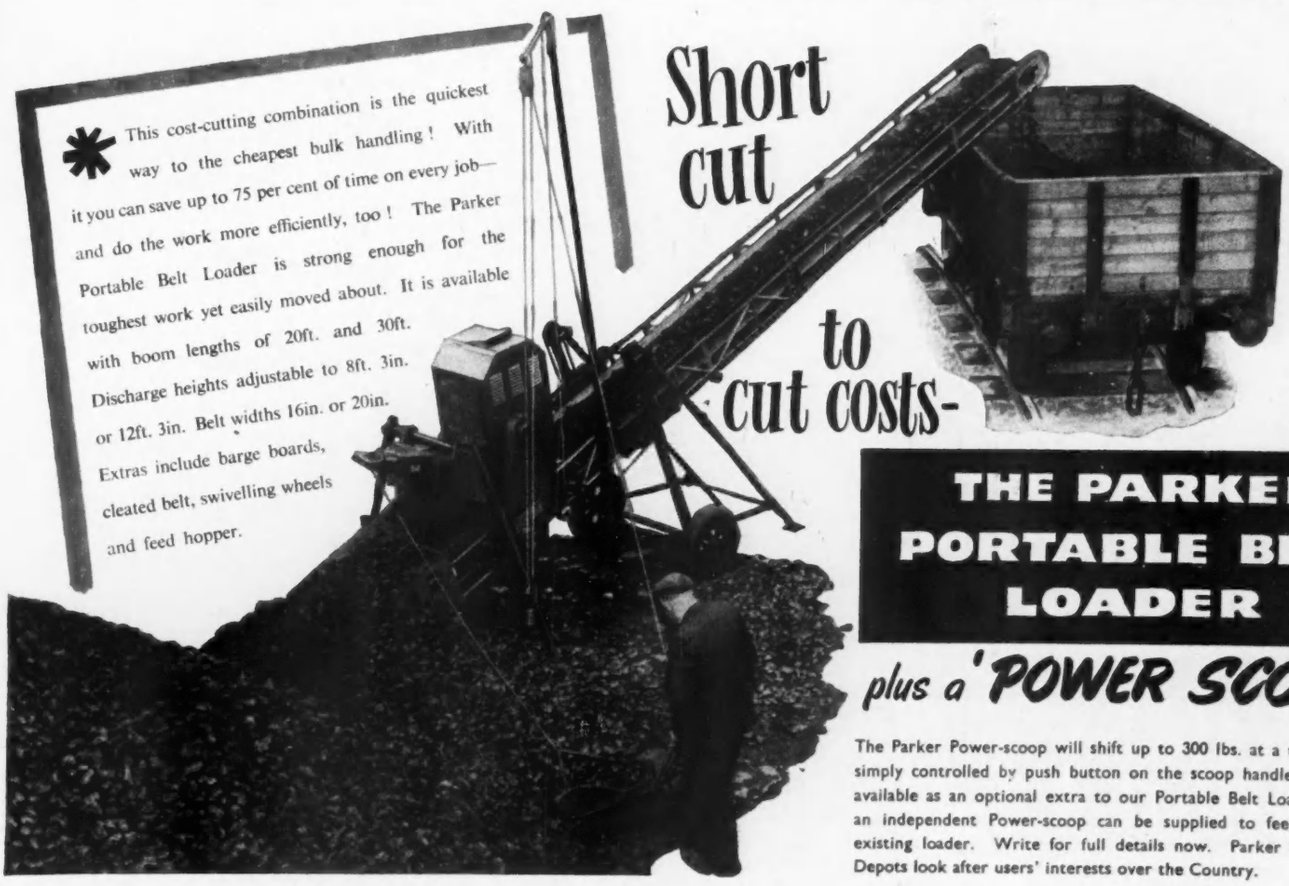

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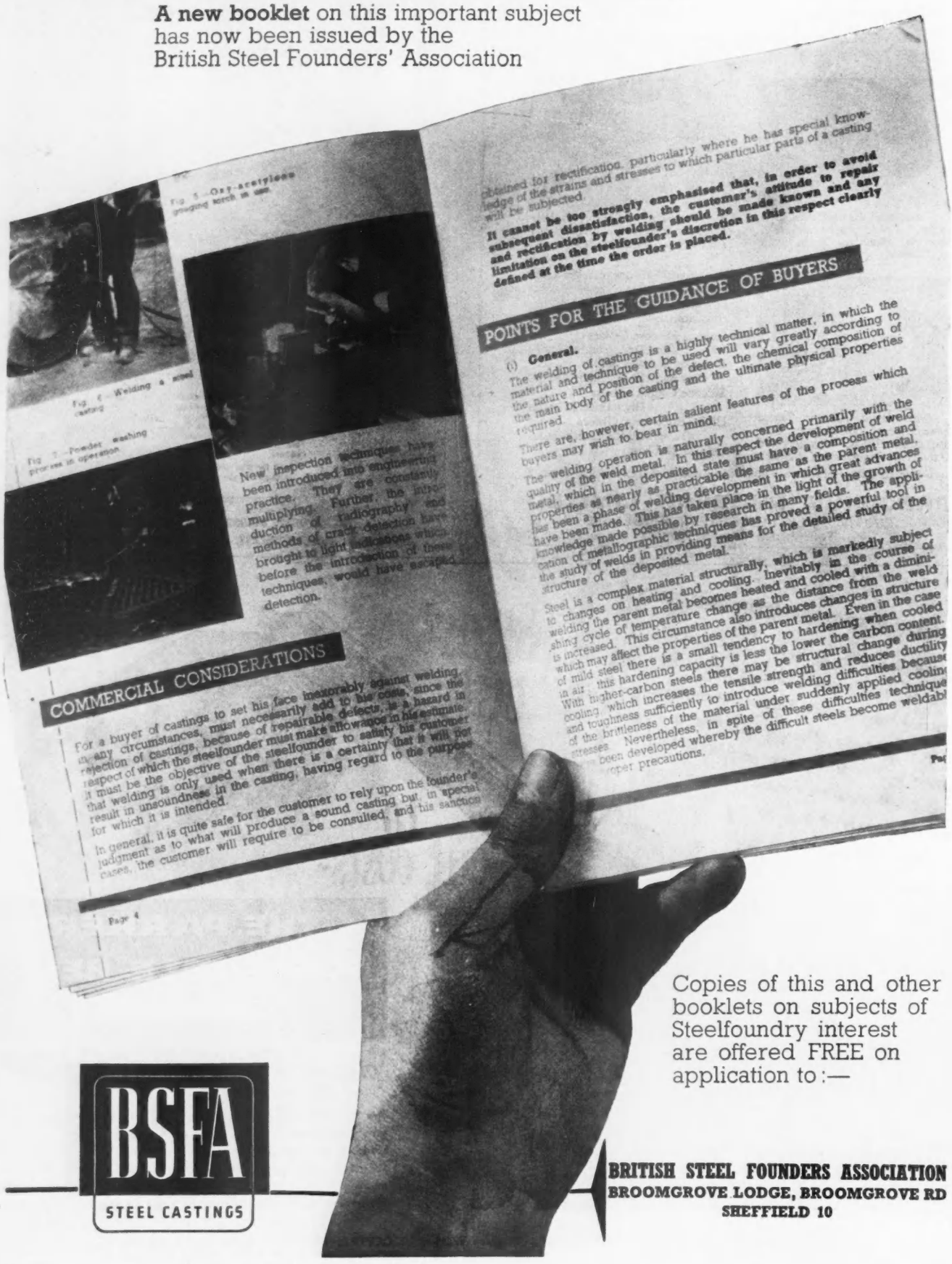

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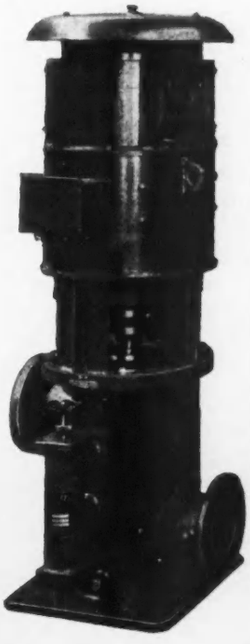

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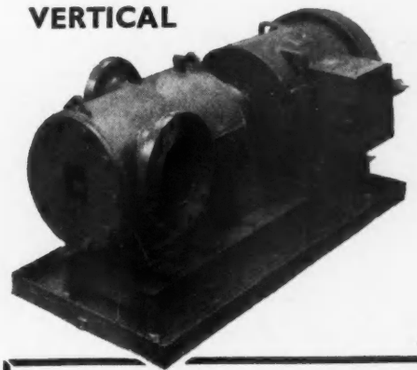

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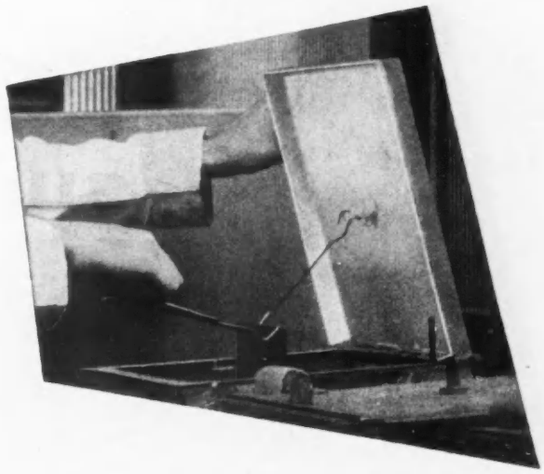

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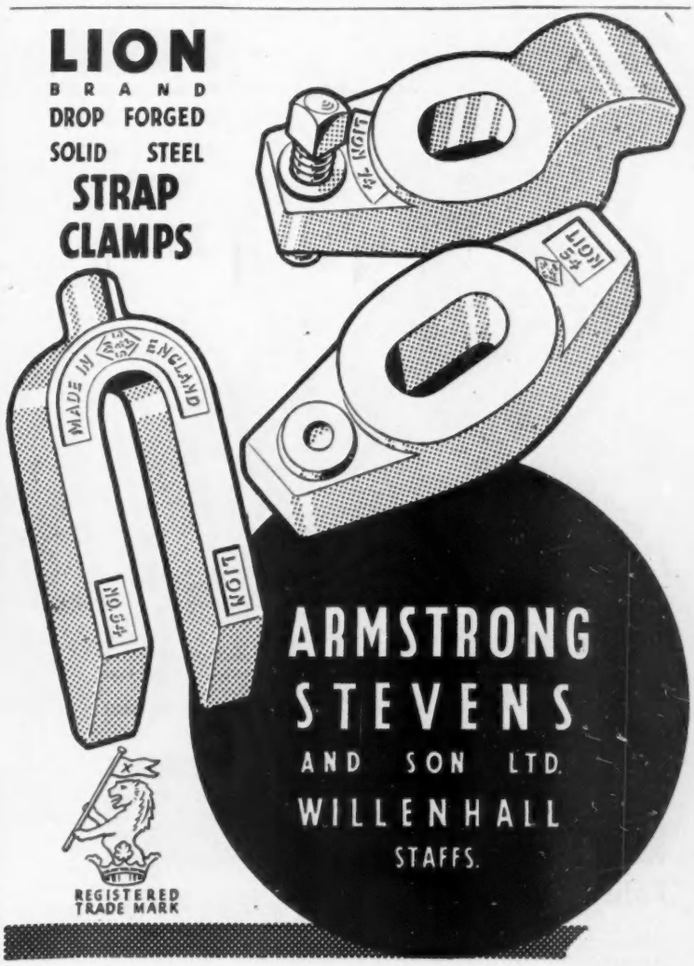

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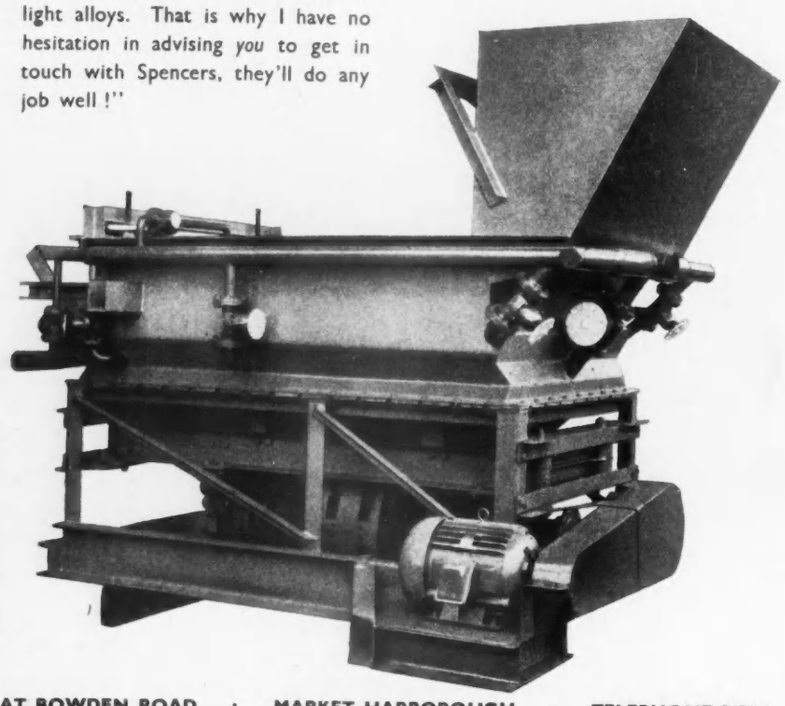

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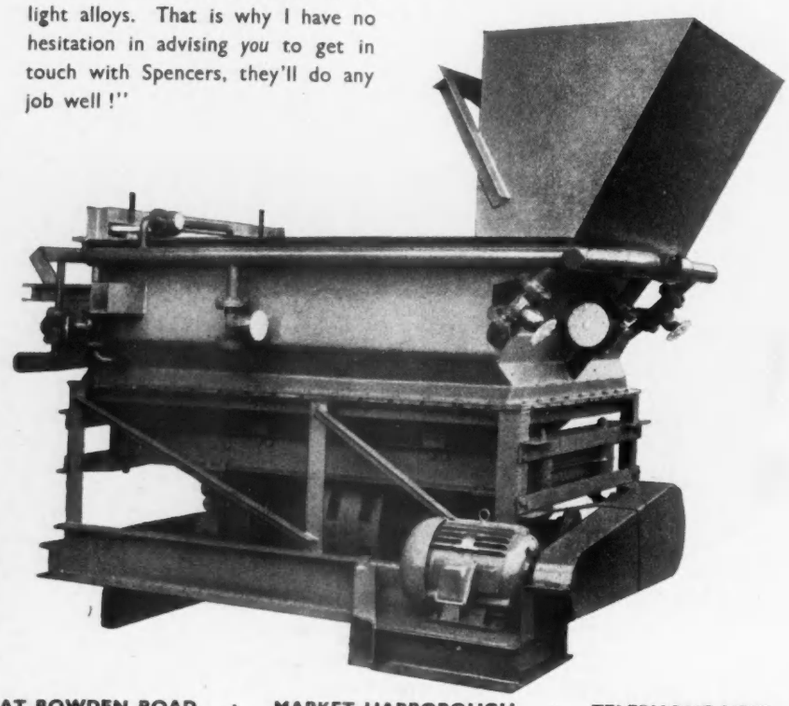

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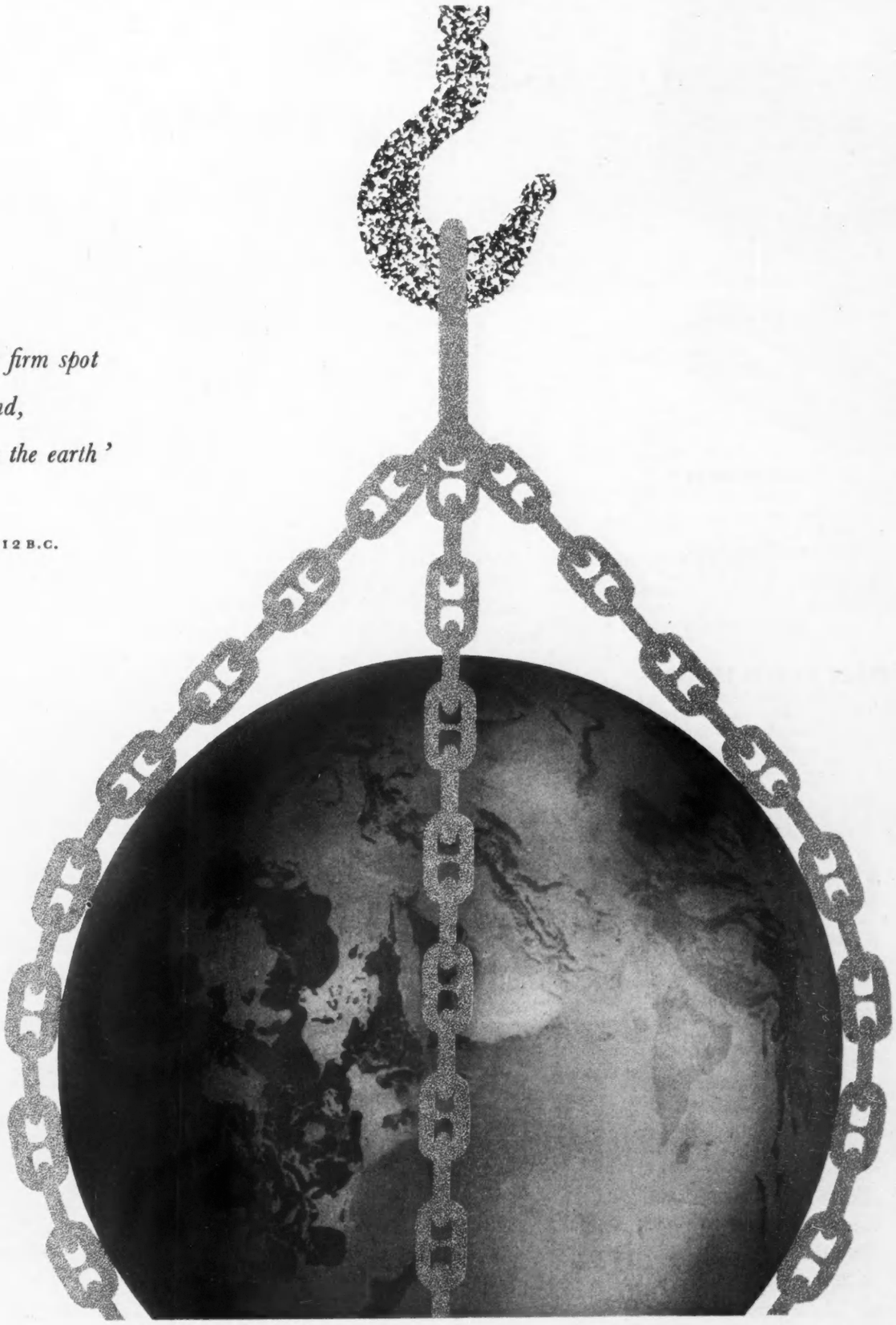

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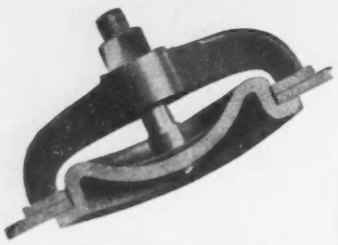

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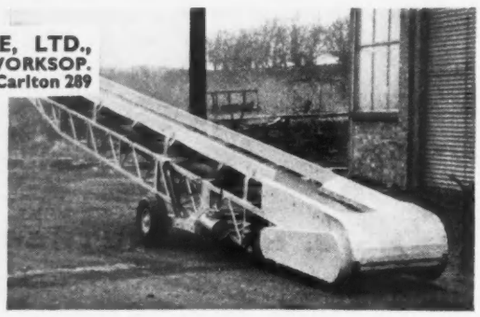

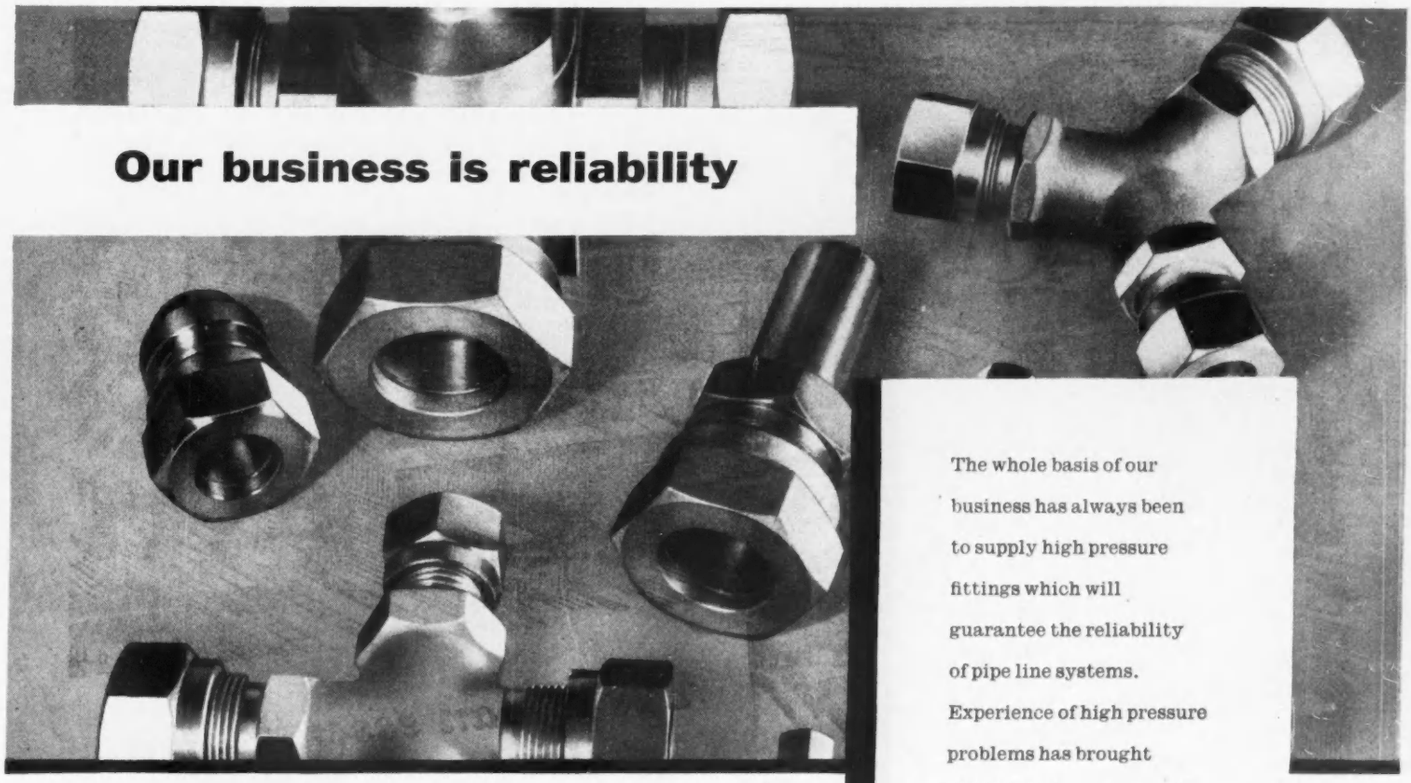

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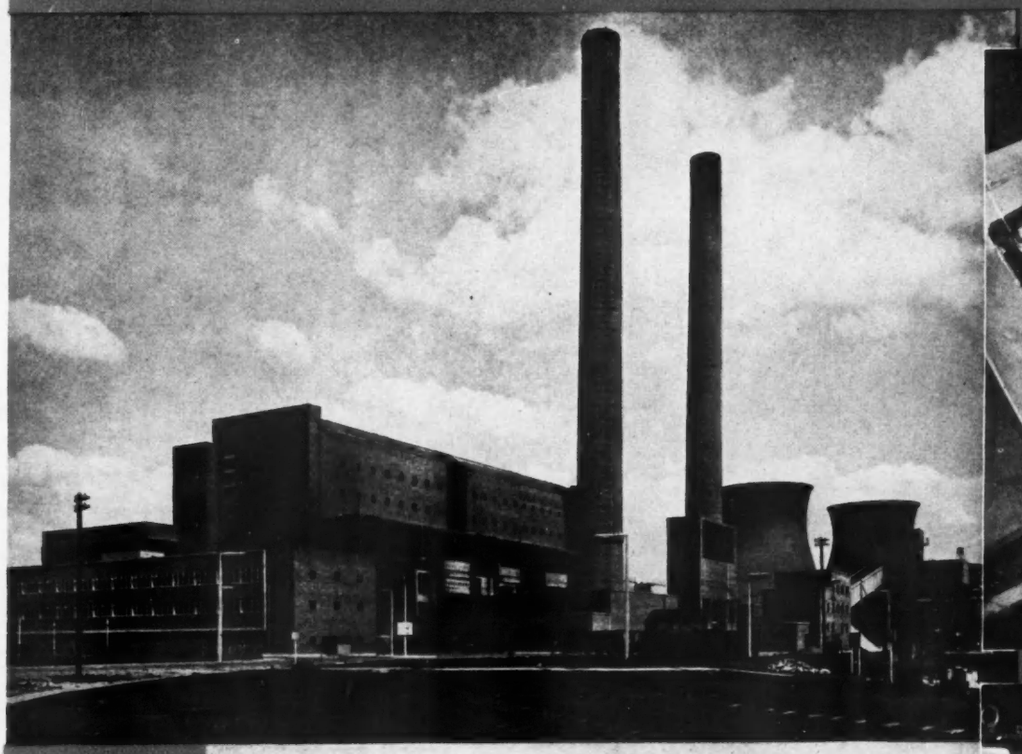

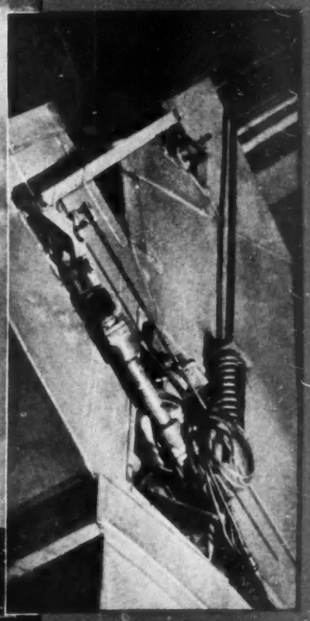

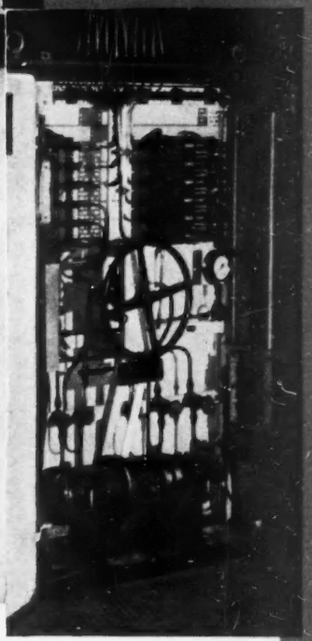

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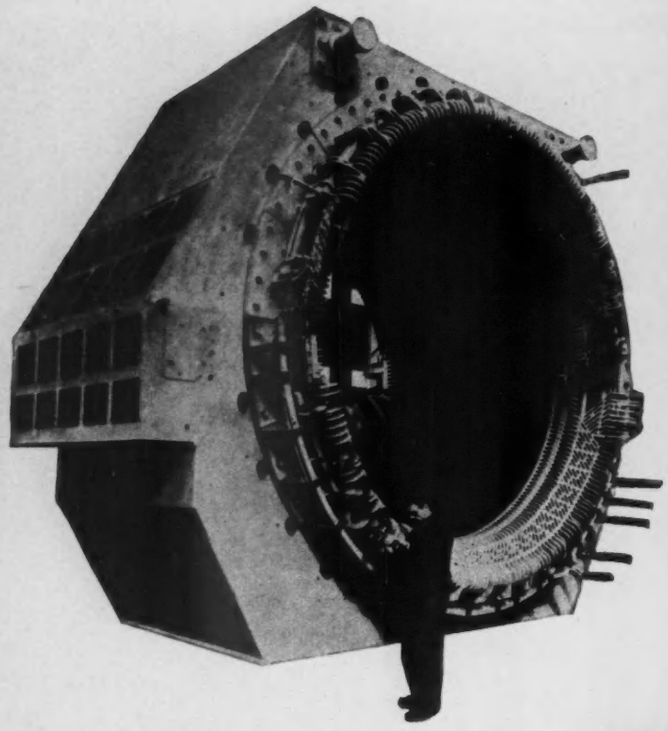

The stator of the 60MW hydro-alternator at Aura Power Station, Norway.

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Wherever there's water in abundance, there's power potential in abundance too. In Scotland, the G.E.C. is helping to harness this power and has supplied the North of Scotland Hydro-electric Board with three 25MW hydro-alternators and control gear for the automatically controlled Errochty Power Station—the largest in the Tummel-Garry scheme.

Norway is another of the water-lands. Here, deep in the mountainside at the head of the Sunndalsfjord is the Aura Power Station. And here a 60MW hydro-alternator has been installed for the Norwegian State Power Company by the G.E.C. In Tasmania, too, the G.E.C. has recently installed five 25MW hydro-alternators at Tungatinah.

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Three 25MW vertical-shaft alternators at Errochty Power Station, Scotland.

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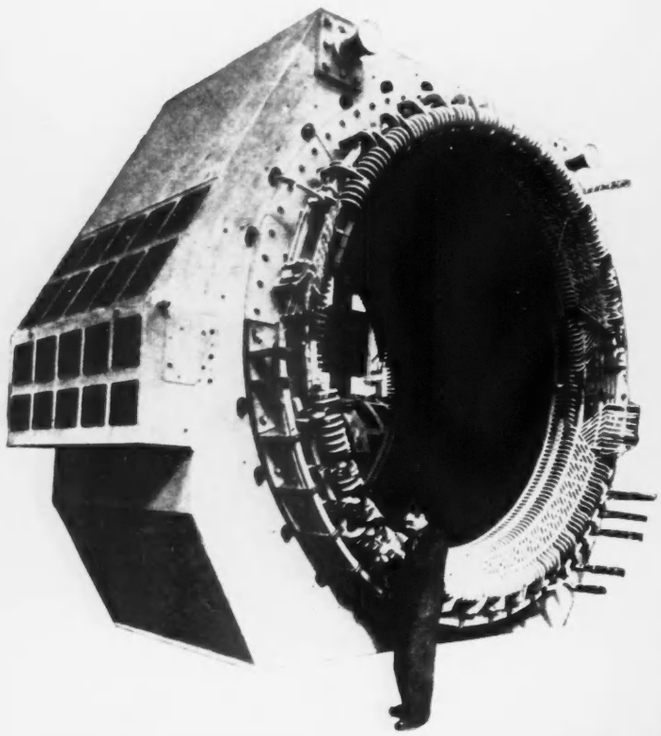

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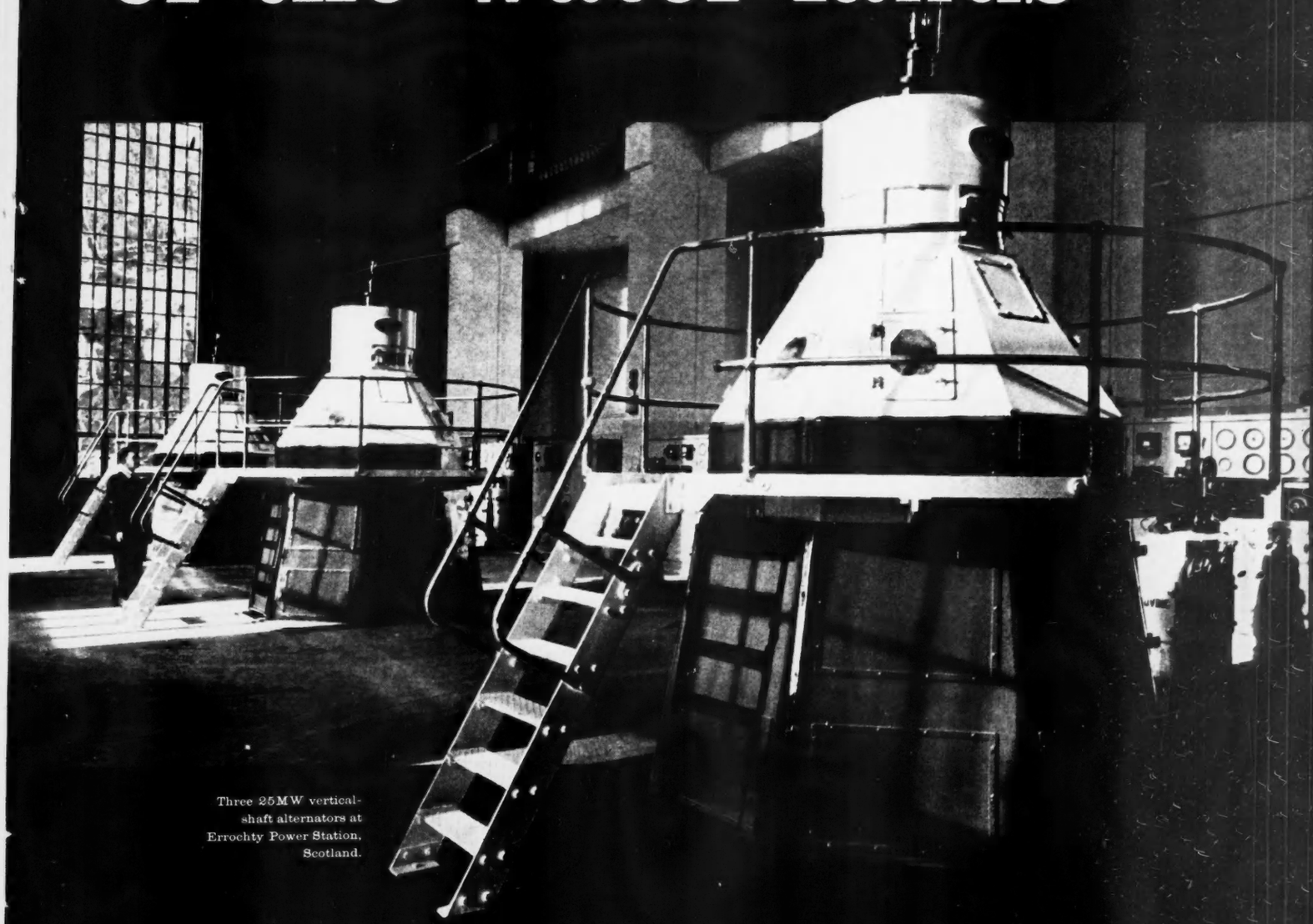

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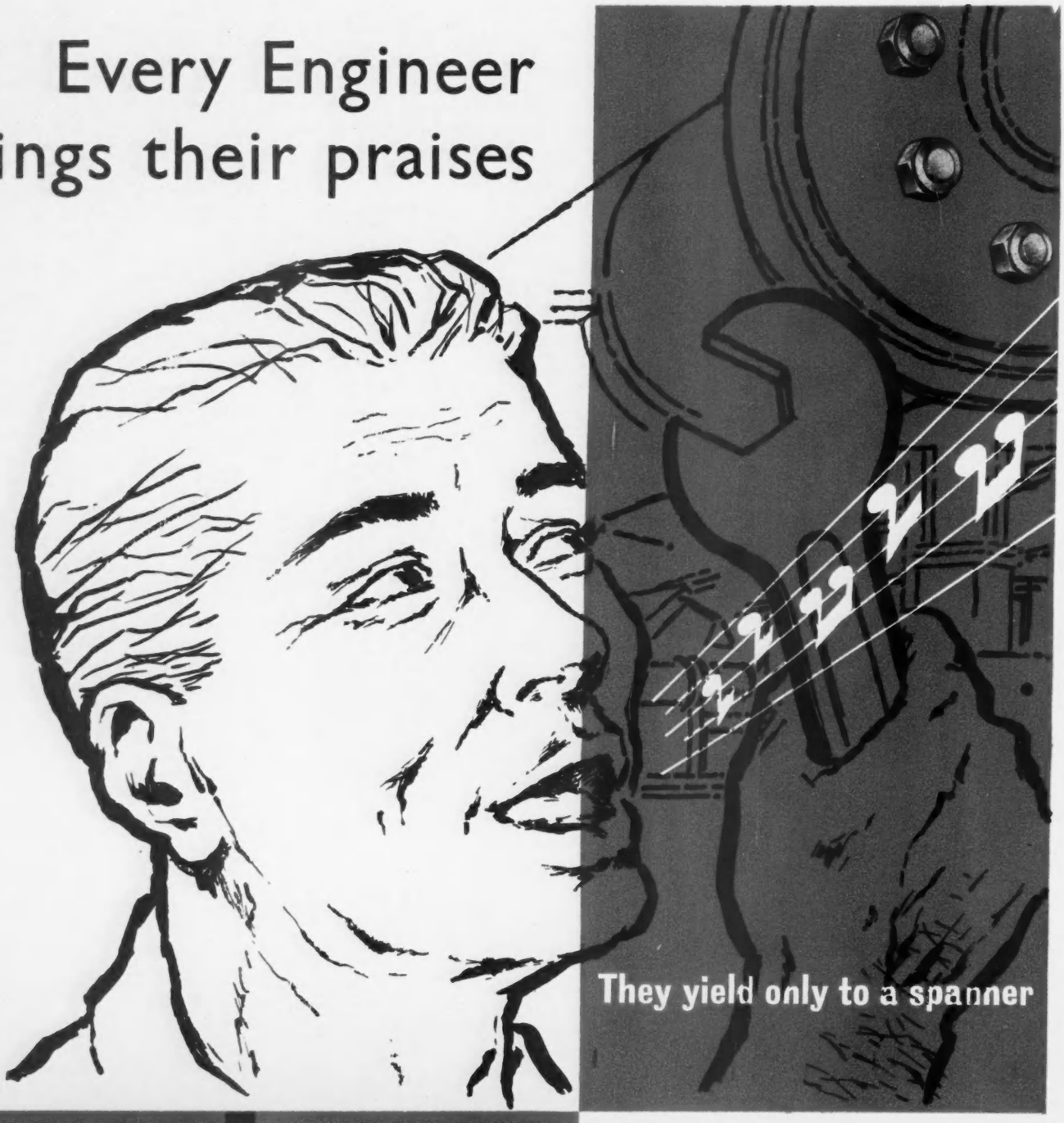

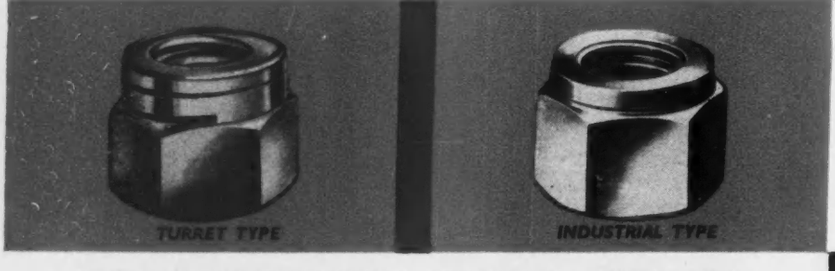

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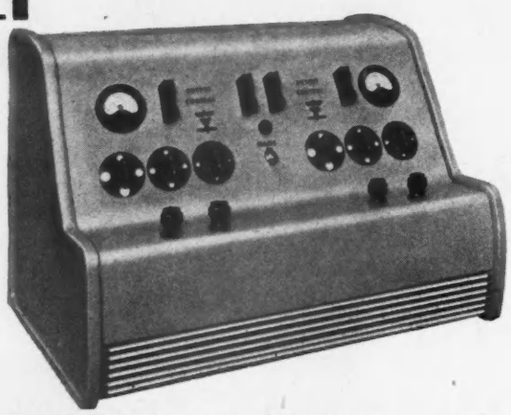

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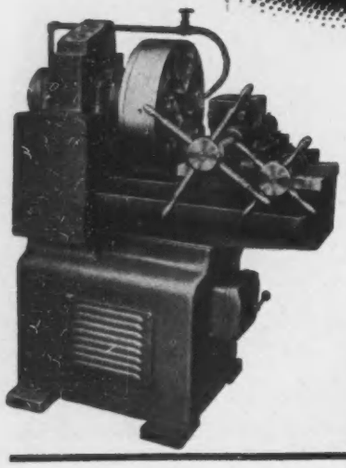

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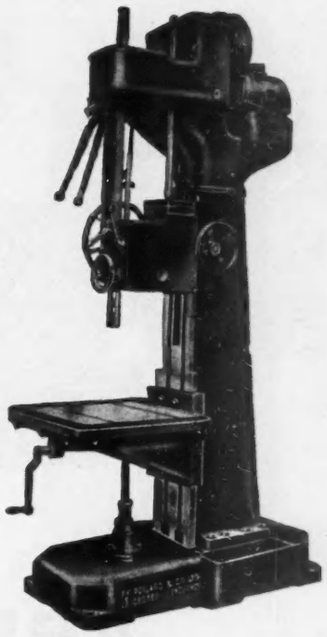

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Nine Spindle Speeds
Variable Automatic Feed

Box Column Models supplied in Gang Drill Form

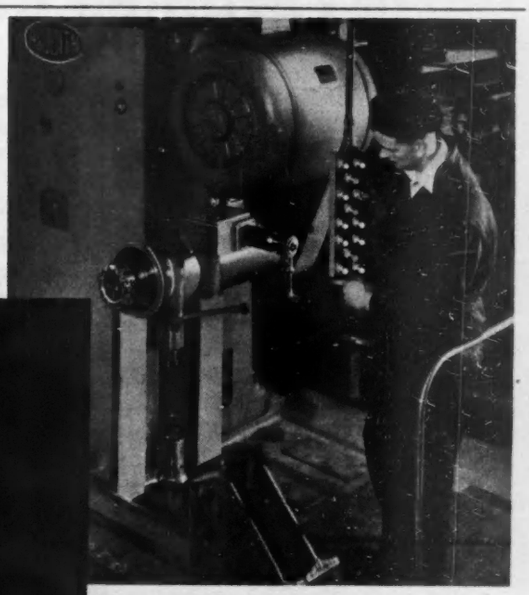
FREDK. POLLARD & CO. LTD.,
CORONA WORKS, LEICESTER
ENGLAND

Telephone *Leicester 67534 (5 lines)*

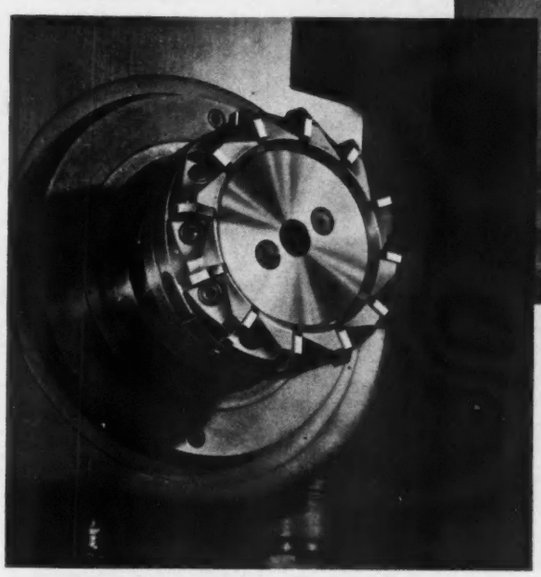
Telegrams *'Corona' Leicester*

LONDON OFFICE: Coastal Chambers, 15 Elizabeth St., Buckingham Palace Road, S.W.1

Prolite FUTUR MILLS
for GIRDER END FACING

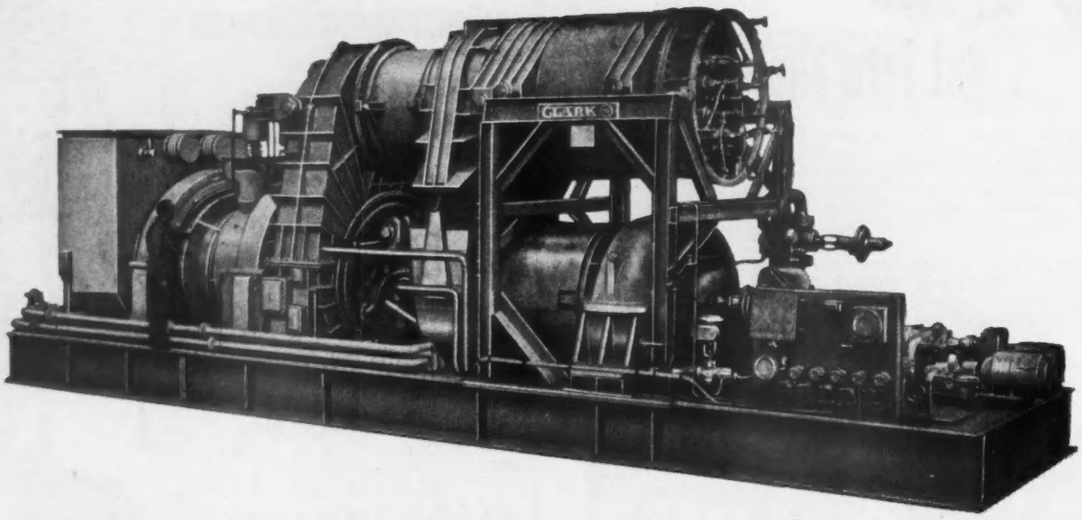


The 'Prolite' Futur Mill has been selected for use on the new Girder End Facing Machine manufactured by William Asquith Ltd. of Halifax. This cutter has proved itself to be ideal for this and similar applications within the constructional steel industry because of the simplicity of servicing, no elaborate cutter grinding being necessary. Its usefulness is, however, not confined to one particular industry; wherever face milling is undertaken the 'Prolite' Futur Mill can prove its merit.



★ *For further particulars please consult our engineers who are always available to assist with all tungsten carbide machining problems.*

Home Sales: **PROTOLITE LIMITED** *(a subsidiary company of Murex Ltd., Rainham, Essex),* **CENTRAL HOUSE, UPPER WOBURN PLACE, LONDON, W.C.1.** *Telephone: EUSton 8265. Telegrams: Prolite, Kincross, London. Export Sales:* **MUREX LIMITED** *(Powder Metallurgy Division),* **RAINHAM, ESSEX.** *Telephone: Rainham, Essex 3322 Telex: 28632. Telegrams: Murex, Rainham-Dagenham Telex.*



ARMSTRONG SIDDELEY to manufacture CLARK Gas Turbines in the United Kingdom

Clark Bros. Co., a division of Dresser A.G., is pleased to announce the appointment of Armstrong Siddeley Motors Limited, member of the Hawker Siddeley Group, as licensed manufacturer of Clark gas turbines in the United Kingdom.

Clark-designed "302" and "305" Gas Turbines, recognized the world over for their dependable quality and performance, are now made with traditional craftsmanship by Armstrong Siddeley Motors. All units are fully backed by the combined engineering skills and world-wide service facilities of the two organizations. Whether made in England, or in the Clark home plant at Olean, New York, all turbine units, as well as components, are identical and interchangeable.

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CLARK BROS. CO.
Ling House, Dominion Street
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ARMSTRONG SIDDELEY MOTORS LIMITED
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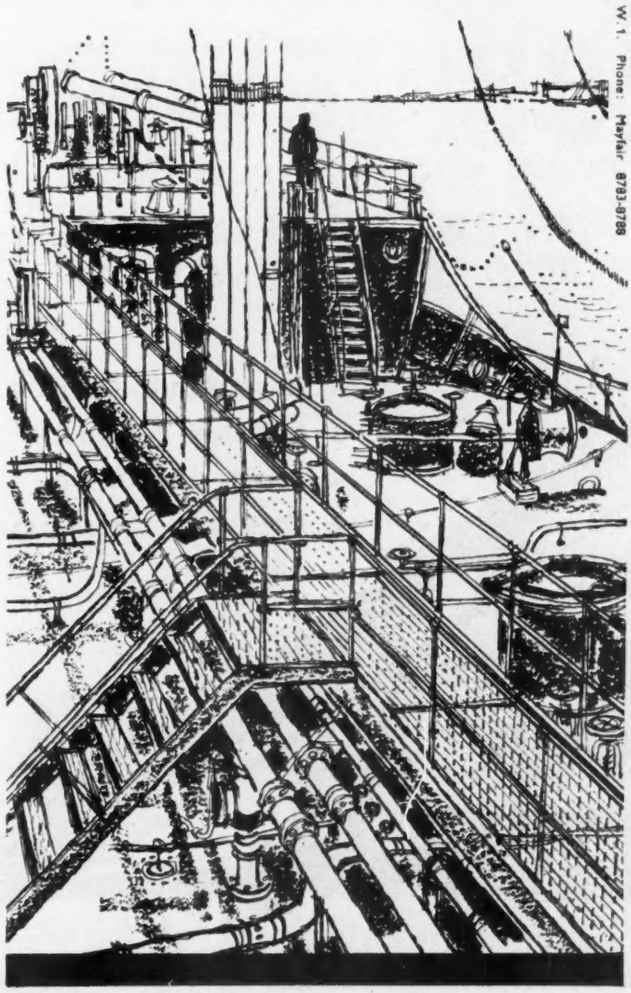

That's the ticket

Look closely at the railway coach you ride in and you will probably find that it features Crompton Parkinson stud welding. Examine the signal gantries it passes and you will certainly come across stud welding again. And, if you were to delve really deeply into the matter, it is more than likely that you would discover it once more on the pit-props in the mine that provided the coal required to provide the electricity which drives the train.

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Crompton Parkinson
ELECTRICAL EQUIPMENT
(STUD WELDING) LIMITED

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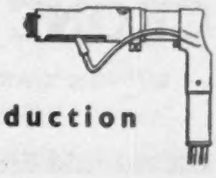
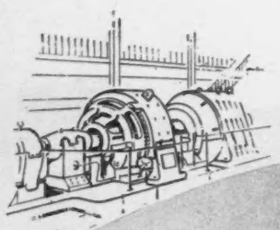
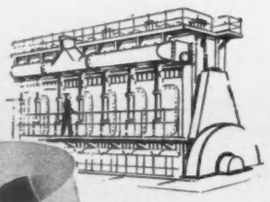
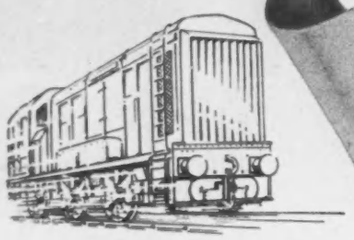


Stud welding steps up production

Everything depends on

BEARINGS



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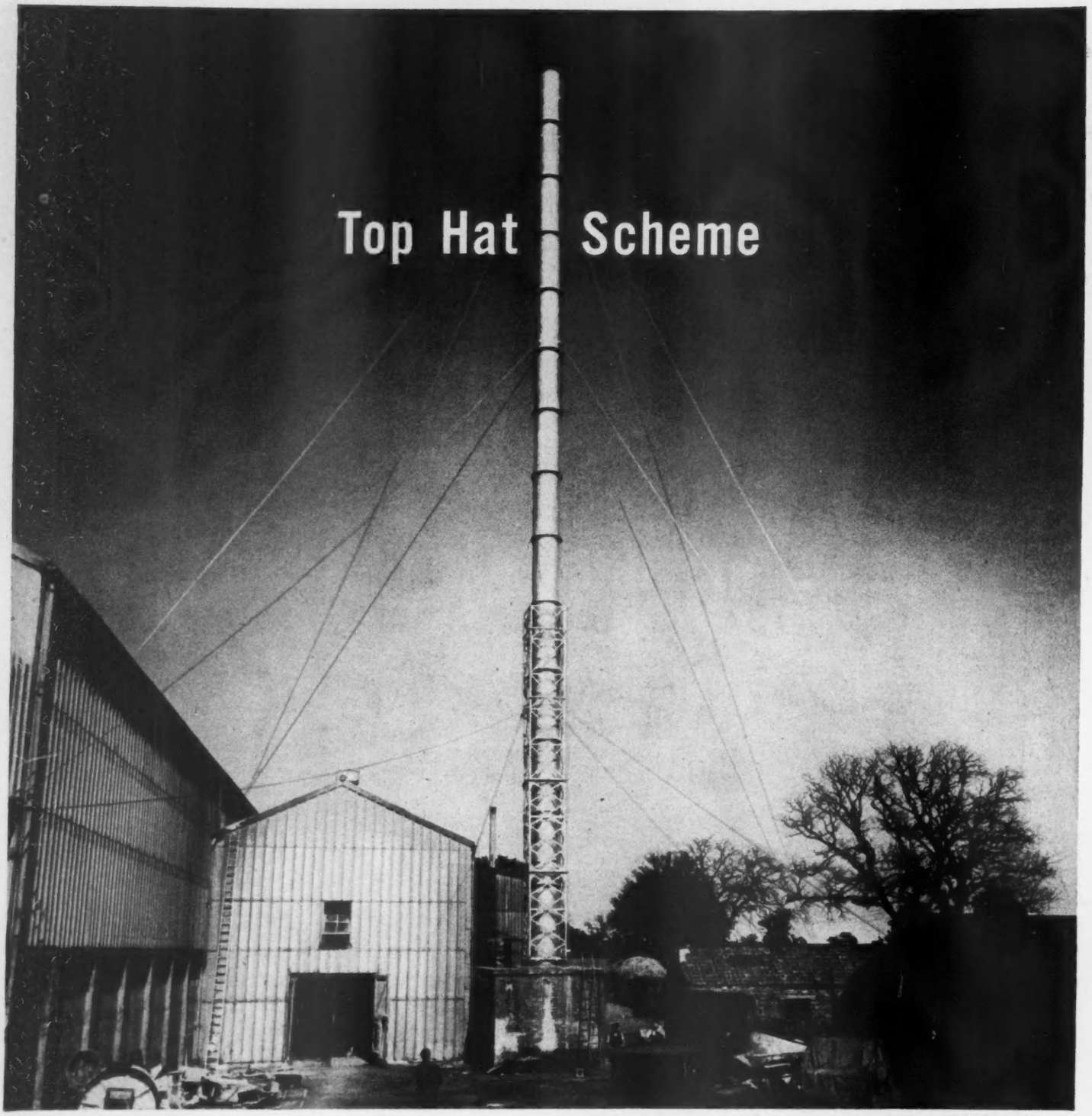

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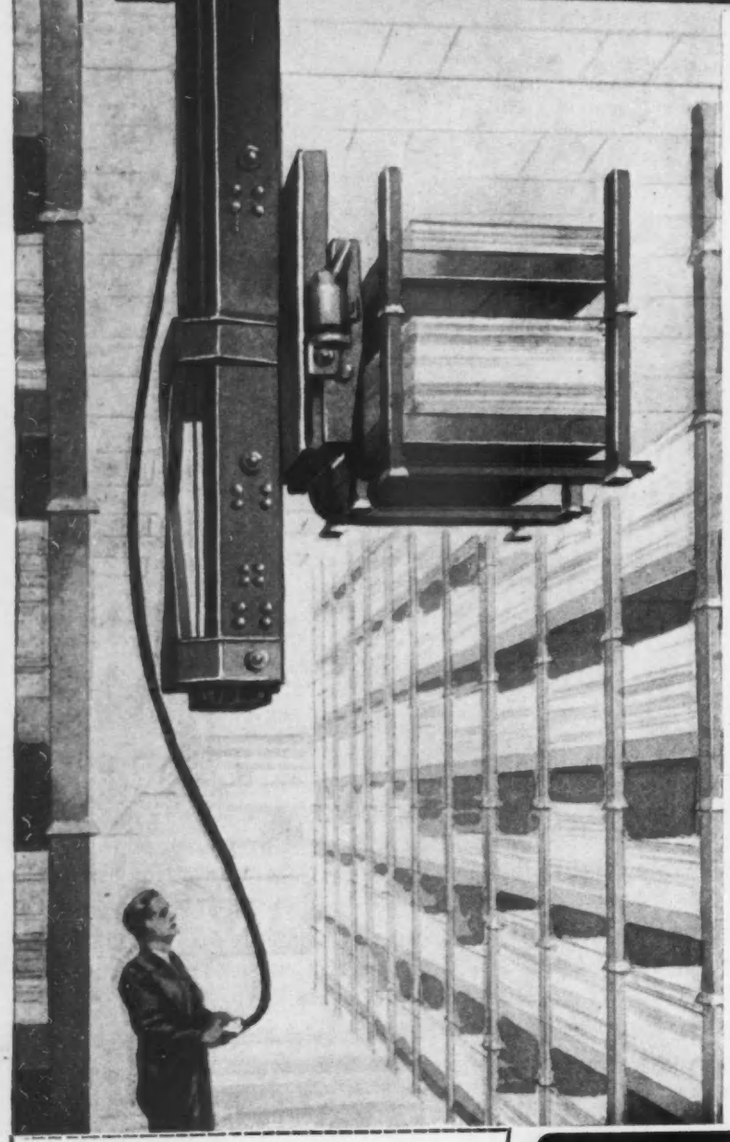

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Now, with a KING SKI-WRACKER you can make every foot of overhead space pay its way. Specially designed to operate in confined spaces where floor-mounted equipment could not, the versatile SKI-WRACKER (exclusive to KING) can stack up to 30ft. high and take loads of 250 lbs.–10,000 lbs.

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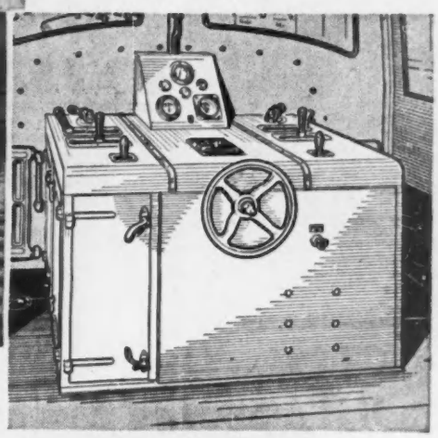
for simplicity... *of control...*

The controls of the Peckett Diesel Locomotive are easy to handle—no special manipulation of throttle or clutch is required for gear changing.



PECKETT *diesels*

The various control levers have been carefully grouped for maximum convenience and are duplicated on either side of the control desk. In conjunction with the extraordinary all-round vision from the fully-enclosed cab, this simplicity greatly minimizes fatigue and mental distraction, and ensures the fullest output from driver and locomotive.

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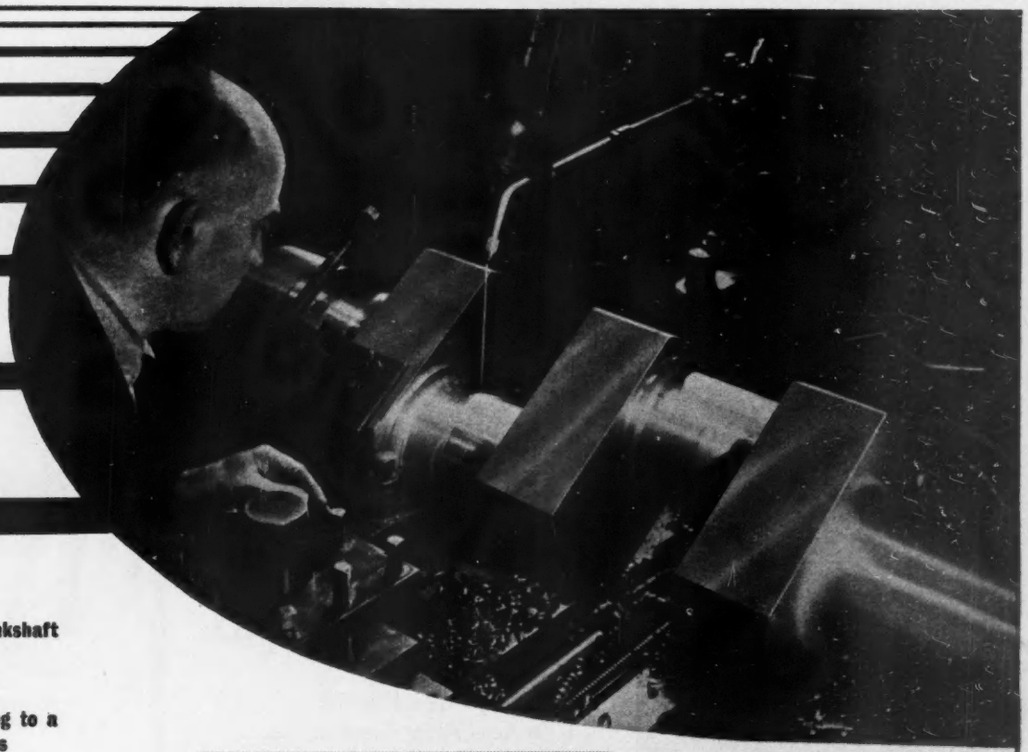
PECKETT & SONS LIMITED, ATLAS LOCOMOTIVE WORKS, ST. GEORGE, BRISTOL 5. Tel: 65-5346. 'Grams: "Peckett" Bristol



This precision machining of a crankshaft is typical of the high standard of workmanship offered by Plowright.

With craftsmen capable of working to a tolerance of ·0005″ and the facilities of modern engineering workshops, Plowright are able to undertake most types of machining and fabrication.

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High Grade Soft Grey Iron & Non Ferrous Castings

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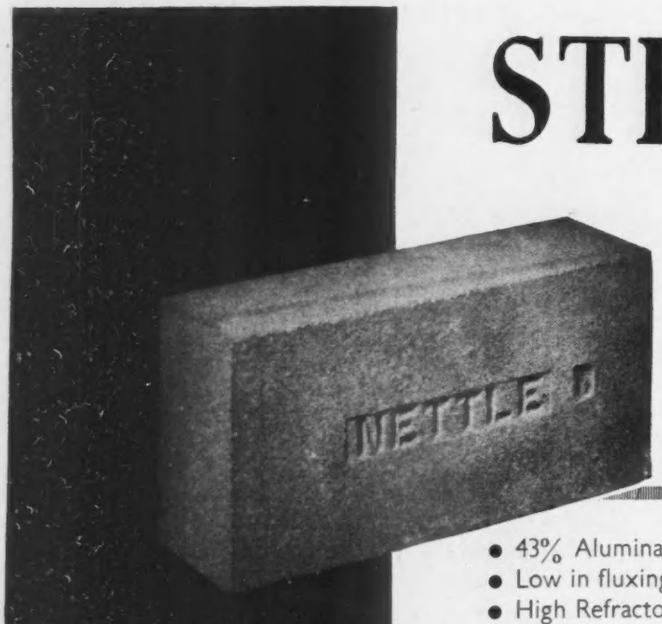
For the General Engineering, Machine Tool & Electrical Trades



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STEIN *Refractories*

NETTLE D—first choice for all applications where service conditions are severe. Nettle D has all the desirable properties looked for in a super duty quality and is designed to give maximum service in furnace positions involving high sustained temperatures, severe slag attack, and abrasion.

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The use of Nettle D in vital furnace positions means longer furnace life, fewer shutdowns and consequent greater output.

Technical Data Sheet gladly sent on request.

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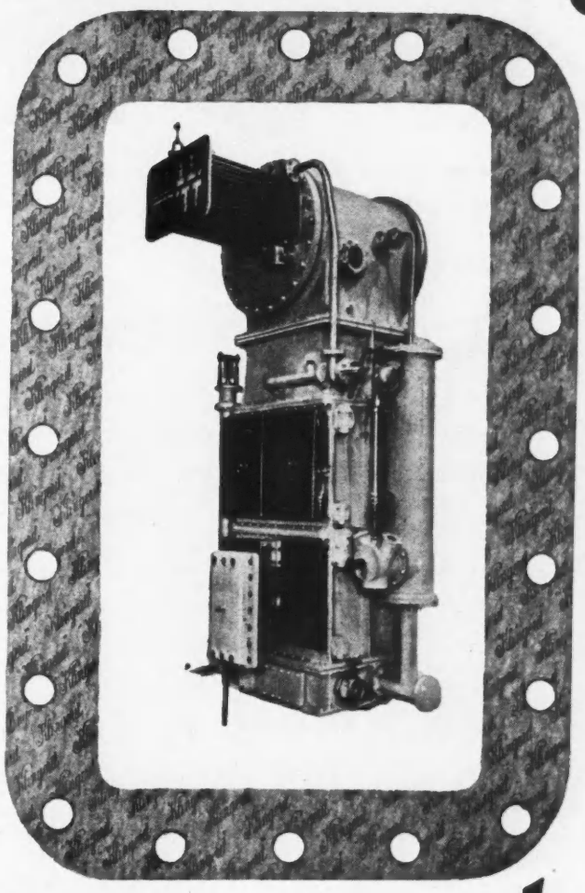

"Klingerit" joints used on the Preheater Condenser tubeplates in an Aiton 20 Tons per day Marine Type Evaporator Distiller. (Photograph by kind permission of Messrs. Aiton & Co. Ltd., Derby.)

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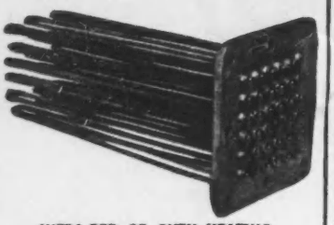

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BRETT'S PATENT LIFTER Co LTD
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"We seem to be getting more out of her since we had those L & C piston rings fitted, chief."

"What was that, sir ?"

"Those L & C piston rings make a great improvement."

"Sorry, sir, I didn't quite get that."

"HAVE YOU GONE DEAF, CHIEF ? I SAID THOSE NEW PISTON RINGS HAVE MADE A WORLD OF DIFFERENCE !"

"Oh ! I don't know about that, sir, but I must say I'm very pleased with the extra performance we're getting down there with those new L & C piston rings Haven't you noticed the difference, sir ?"

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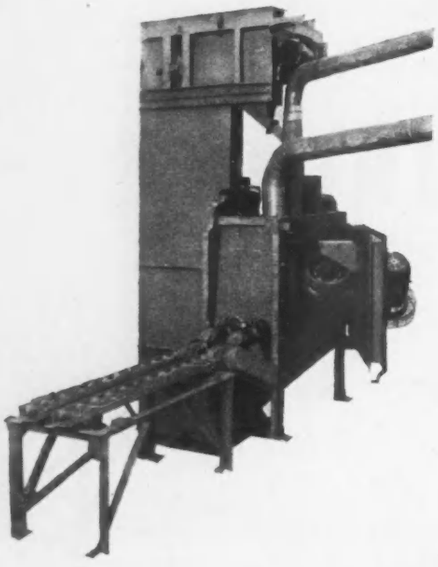

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THE PHOTOGRAPH SHOWS A RECENTLY INSTALLED AIRLESS PLANT WITH A SINGLE IMPELLOR CLEANING SIMULTANEOUSLY TWO BARS OF OVAL SECTION. THE BARS ARE TRAVERSED THROUGH THE CABINET ON BELT CONVEYORS WHICH ARE OSCILLATED.

EASY ACCESS TO WORKING PARTS IS OBTAINED BY MOUNTING THE IMPELLOR AND ITS MOTOR ON A SWING DOOR SUITABLY MOUNTED FOR RIGIDITY.

LET US QUOTE FOR YOUR SPECIAL REQUIREMENTS

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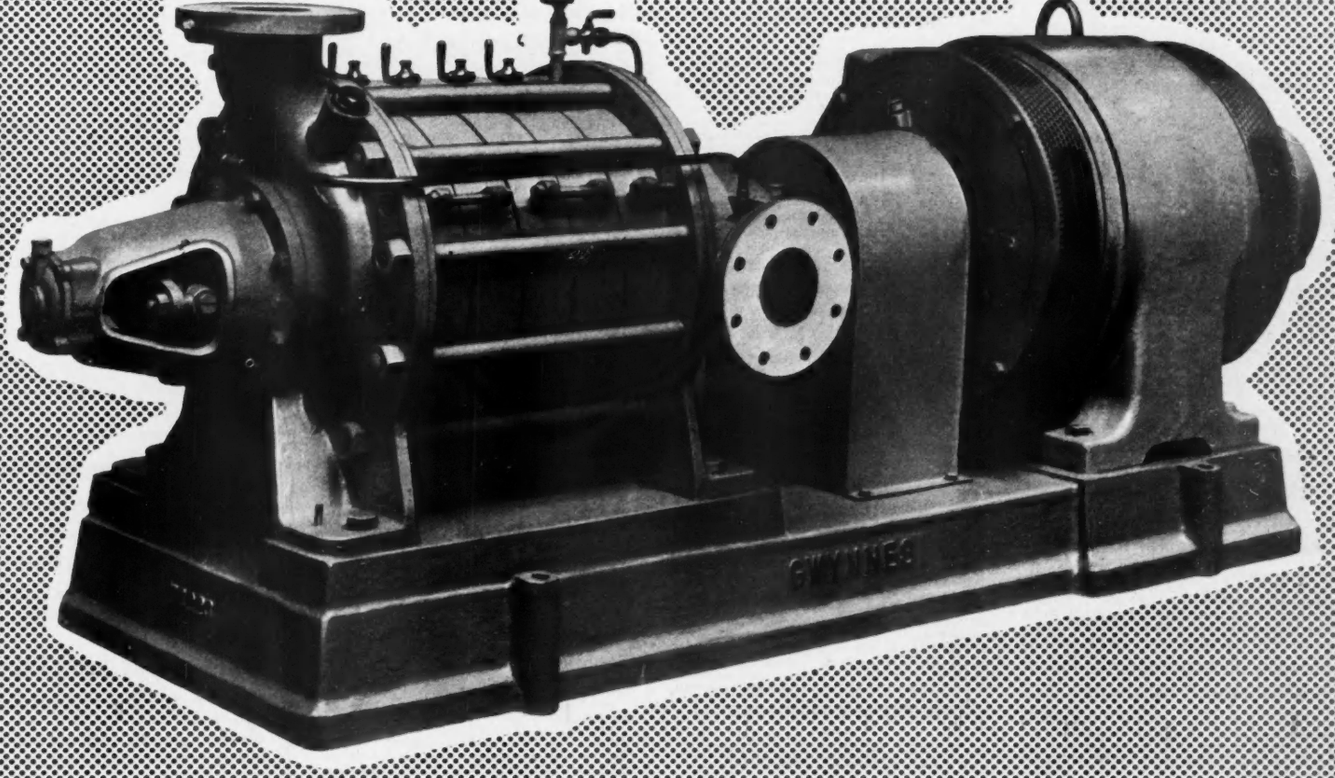
TELEPHONE: DEANSGATE 4648-9. TELEGRAMS: BLAST, MANCHESTER.

Gwynnes STANDARD Multi-stage Pressure pumps



Gwynnes standard multi-stage turbine pressure pumps are from 1½" size to 9". The stages vary between two and eight to suit the head requirements. Larger pumps or pumps with more stages are supplied to meet specific requirements.

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Use of Box Number. 2/- which includes forwarding of replies.
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Urgent advertisements may be telephoned to CENtral 6565.

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COLLEGE OF TECHNOLOGY

Principal: S. A. J. PARSONS, B.Sc. (Econ.), M.I.Mech.E., M.I.Prod.E., M.B.I.M.

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The Governing Body invites applications from suitably qualified persons for the appointment of LECTURER (full-time) IN MECHANICAL ENGINEERING. Duties to commence as soon as possible.

Salary, Men: £1200 by £30 to £1350 per annum. (1956 Burnham Technical Report.) Commencing salary on this scale may be assessed according to previous industrial or professional experience.

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Further particulars and application form (returnable by 3rd October, 1958) may be obtained from the Director of Education, 14, Sir Thomas Street, Liverpool, 1.

THOMAS ALKER,
Town Clerk and Clerk to the Local Education Authority.

(J.5320)2 E8632

UNIVERSITY OF BRISTOL

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Applications, including the names of two persons to whom reference may be made, should be sent not later than 13th October, 1958, to the Registrar, the University, Bristol, 8, from whom further particulars may be obtained. E8629

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The salary range is £A2100 to £A2500 per annum. Starting salary will be determined according to qualifications and experience. Superannuation similar to F.S.S.U. in Great Britain will be provided.

Conditions of appointment may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

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CITY OF NOTTINGHAM

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Applications for this permanent, pensionable appointment are invited from Engineering Graduates with at least 5 years' experience, and should be sent to the Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, by the 29th September next, with the names of 2 persons to whom reference may be made. Salary according to experience in the Special Grade, £750 by £40 to £1030.

T. J. OWEN,
Town Clerk.

Guildhall,
Nottingham. E8623

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REGIONAL TECHNICAL INFORMATION OFFICER

Applications are invited for the post of REGIONAL TECHNICAL INFORMATION OFFICER, to be based on the College. Applicants should be qualified in pure and applied science with a broad background of knowledge and experience.

In the first instance the post is temporary for eighteen months. The salary offered will be between £1350–£1550, depending upon qualifications and experience.

Further particulars may be obtained from the Principal, at the College, Cathays Park, Cardiff.

ROBERT E. PRESSWOOD,
Clerk to the Governors.

City Hall,
Cardiff.
September, 1958. E8614

MINISTRY OF SUPPLY RESEARCH AND DEVELOPMENT ESTABLISHMENTS

SCIENTIFIC OFFICERS

Ministry of Supply Research and Development Establishments, mainly in southern half of England, require: (a) SENIOR SCIENTIFIC OFFICERS (minimum age 26) and (b) SCIENTIFIC OFFICERS, for work in Physics, Electronics, Electrical or Mechanical Engineering, Applied Mathematics, Aerodynamics, Chemistry or Metallurgy. 1st or 2nd Class Hons. Degree or equivalent required and for S.S.O. at least 3 years' post-graduate experience.

Starting salary in range: (a) £1130–£1330; (b) £595–£1050 (male, in provinces). Rates for women reaching equality in 1961. Superannuation under F.S.S.U. Opportunity for those under 32 to compete for established posts. Candidates should indicate fields of work in which interested.

At National Gas Turbine Establishment, Pyestock, Hants, houses available for letting to married staff, and opportunities for new graduates to have workshop training.

Forms from M.L.N.S. Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.300/8A). E8328

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS (a) SCIENTIFIC OFFICERS (b)

Pensionable posts for men and women in major scientific fields, including meteorology and geophysics frequent overseas surveys). A few vacancies for biologists, including specialised posts in taxonomy of invertebrate animals, fungus systematics, and one post for a Taxonomic Botanist (Pteridophya). Also one post in Home Office for Mathematician/Physicist to work on Civil Defence problems. Qualifications: normally First or Second Class Honours Degree in Science, Mathematics or Engineering, or equivalent attainment; additionally, for (a) at least 3 years' relevant (e.g. post-graduate) experience. Normal age limits: (a) between 26 and 31, (b) between 21 and 28, with extensions for regular Forces service and Overseas Civil Service. London salaries (men): (a) £1190–£1410, (b) £635–£1110. Five-day week generally.—Write, Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting (a) S.53/58, (b) S.52/58. E8612

MANCHESTER CORPORATION WATERWORKS

ASSISTANT ENGINEERS

Applications are invited for the undermentioned appointments in connection with the design and construction of treatment and filtration plant, and large service reservoirs, the reconstruction of existing reservoirs, and the reconditioning of main aqueduct:

ASSISTANT ENGINEERS (Class II)—£750–£1030.

ASSISTANT ENGINEERS (Class III)—£575–£845.

Applications stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of waterworks or other civil engineering works, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, not later than 6th October, 1958. E8624

COUNTY BOROUGH OF BOLTON

WATERWORKS DEPARTMENT

ENGINEERING ASSISTANT

Applications invited for appointment of ENGINEERING ASSISTANT, Grade A.P.T. IV (£1025–£1175). Candidates must be Chartered Engineers (Civil or Mechanical) and have experience in the design, construction or operation of waterworks plant or structures. The appointment is superannuable subject to medical examination. House available if required.

Applications giving details of age, training, qualifications and experience and naming three referees, must be received by me not later than 6th October.

PHILIP S. RENNISON,
Town Clerk
E8626

CIVIL SERVICE COMMISSION

CIVIL ENGINEERS

Pensionable posts for men and women aged 25 and under 35 on 1st January, 1958; extension for regular Forces service, H.M. overseas civil service, established civil service, and temporary government service as Civil Engineer. Candidates must have achieved Corporate Membership of Institution of Civil Engineers or passed examinations necessary for attaining Corporate Membership. Men's starting salary from £755 to £1085. Maximum (London) £1250. Promotion prospects.—Write Civil Service Commission, 30, Old Burlington Street, London, W.1, for application form, quoting S64/58. E8621

NORTH EAST METROPOLITAN REGIONAL HOSPITAL BOARD

SENIOR ASSISTANT ENGINEER (MECHANICAL)

Applicants must be Corporate Members of the Institution of Mechanical Engineers, unless professionally graded in the National Health Service, and should possess experience in a senior capacity in the design of boiler plants, steam, heating, hot water and ventilating systems, and have a sound knowledge of all associated mechanical equipment, although not necessarily in the field of hospital engineering. Experience of large-scale laundry equipment an advantage.

Salary £1010 by £30 (5) by £35 (1) to £1195 per annum, plus London Weighting £50.

Applications, giving age, present salary, qualifications and experience (with dates), together with the names of two referees should be sent to the Secretary, North East Metropolitan Regional Hospital Board, 11a, Portland Place, W.1, within 14 days. E8631

EAST ANGLIAN REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER (MECHANICAL)

ASSISTANT ENGINEER (MECHANICAL)—Candidates should be A.M.I.H.V.E. or Graduate Members of I.H.V.E. or equivalent. Experience in design and installation of heating, ventilating, steam boiler plant and services, &c., as applicable to hospitals desirable but not essential. Salary £700–£1015—additional increments within scale based on experience and age may be granted.

Applications, stating age, qualifications, experience and details of present position (salary, &c.), with names of three referees, to Secretary of Board, 117, Chesterton Road Cambridge, by 30th September, 1958. E8508

NATIONAL COAL BOARD

NORTH EASTERN DIVISION

CIVIL ENGINEERING ASSISTANT

CIVIL ENGINEERING ASSISTANT required in the No. 8 (Castleford) Area, salary £750–£1150 per annum.

Candidates should have experience in the design and construction of industrial works in reinforced concrete/structural steel or general civil engineering works including roads, railways and drainage. Experience in the preparation of Specifications and Bills of Quantities will be an advantage. Applicants must have passed Sections I and II of the Institution of Civil Engineers' Associate Membership Examinations or possess an equivalent qualification.

Apply to Area Staff Manager, Allerton Bywater, Castleford, Yorks, by 11th October, 1958. E8628

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

ASSISTANT CHIEF ENGINEER (DESIGN)

An ASSISTANT CHIEF ENGINEER is required to be responsible to the Head of the Design and Production Group for the direction of design teams at Harwell and Bracknell (comprising professional engineers and design and ancillary staff) and for the control of the main drawing-offices at both establishments. The work covers a wide range of engineering and scientific projects.

Applicants should be professional engineers (members of a senior engineering institution) with considerable experience of project and design office management and in the design of mechanical, electrical or chemical plant. Knowledge of the practical problems involved in handling toxic or radio-active materials or in high voltage/high frequency work, including vacuum circuits, is desirable.

Salary on appointment: between £2100 and £2600.

The Group Recruitment Officer (1211/25), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks, will supply further details of the appointment. E8619

NUCLEAR PLANT INSTRUMENTATION

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(Industrial Group Headquarters), Risley, Warrington, Lancashire,

requires

INSTRUMENT ENGINEERS

to lead one or more teams of engineers and draughtsmen engaged in the design of measuring and control systems for Authority projects, which include chemical plant and nuclear reactors.

Technical judgment of a high order and extensive experience in the field of modern industrial instrumentation are essential, and the varied and complex problems encountered demand a flexible outlook and a sound knowledge of modern electronics and radioactivity measuring techniques.

A recognised engineering apprenticeship or comparable training and corporate membership of a senior engineering institution, or equivalent, are essential.

Salary between

£1300–£2080

according to qualifications and experience.

Contributory Pension Scheme.

Housing or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting reference 2587, to Recruitment Officer, I.G.H.Q., Risley, Warrington, Lancashire.

Closing Date: 29th September, 1958.

E8589

TENDERS

GOVERNMENT OF NEW ZEALAND MINISTRY OF WORKS

WAIRAKEI GEOTHERMAL PROJECT

HOT WATER TRANSMISSION

TENDERS will shortly be invited for the SUPPLY and ERECTION of a HOT WATER PIPELINE about 4500ft. in total length, consisting partly of 19in. nominal bore and partly 17in. nominal bore pipes. The contract will also include branch lines of smaller bores, sundry pressure vessels, including a head tank 7ft. diameter by 20ft. high, sundry valves, expansion compensators, &c. The working pressures range from 250 lb. to 350 lb./sq. in g.

Interested firms should apply to Merz and McLellan, Millburn, Esher, Surrey, England, for full particulars. No further announcement will appear, and this notice should be regarded as a formal invitation to Tender. E8591

INDIA SUPPLY MISSION

TENDERS are invited by India Supply Mission, 2536, Massachusetts Avenue, N.W. Washington 8, D.C., for the supply of approximately 18,000 long tons of STEEL STRUCTURALS, PLATES, SHEETS, BARS, ROUNDS required for locomotive and wagon building and bridge girders for Indian Railways. Tenders are priced at $2.00 (Sh. 14/3) per set and can be obtained on request from the Office of Director-General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3.—Please quote reference Tender No. SD-2. Tender closing date October 6th, 1958. E8615

EDUCATIONAL

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIP

University of London King's College offers a RESEARCH STUDENTSHIP, made available by Usines Emile Henricot, S.A., and tenable in the College for one year with possible renewal for a second year. The value will be £500 a year. The Studentship is for research into various aspects of the mechanical behaviour of ball mills ; the character of the research is such that it should lead to a Higher Degree.—Applicants should have a good Honours degree in some branch of Engineering.—Particulars and application forms from the Registrar, King's College, Strand, W.C.2, whom completed forms must reach by October 6th. E8512 E

EDUCATIONAL

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIPS

University of London King's College offers the following RESEARCH STUDENTSHIPS, made available by Joseph Lucas, Ltd., and tenable in the College for one year with possible renewal for a second year.

(a) One of £800 a year for research into the initiation of explosions in gases, vapours and powder clouds.

(b) One of £500 a year for research into the mixing of powdered materials.

The character of the researches is such as should lead to a Higher Degree. Applicants for (a) should have a good Honours degree in Mechanical or Electrical Engineering of Physics and preferably some research experience.

Applicants for (b) should have a good Honours degree in some branch of Engineering, Physics and Chemistry.

Particulars and application forms from the Registrar, King's College, London, Strand, W.C.2., whom completed forms must reach by October 6th. E8511 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN

(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

BOOKS and PUBLICATIONS

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Telephone: Central 6565

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN ENGINEER IS REQUIRED who is familiar with the commissioning of mechanical power plant and its associated auxiliaries. Academic qualifications up to Higher National Certificate or equivalent are desirable. It is essential that previous extensive experience in this class of work has been acquired. The successful candidate must be prepared to travel and, if necessary, take up residence abroad for periods up to six months. Familiarity with gas turbine engineering an advantage, but not essential. —Applications giving details of training, qualifications and experience to date should be sent to the Personnel Officer, Ewbank and Partners, Ltd., 10/11, Grosvenor Place, S.W.1. E8630 A

AGENT with connections with Architects, Engineers and Industrial Undertakings, required to Represent Constructional Steelwork and Platework Engineers.—BOX No. E2085, "The Engineer." A

APPLICATIONS are invited for the position of CHIEF ENGINEER of an important manufacturing company (not engineering), comprising three factories with 5000 employees in Southern England.

This is one of the top positions in this field that industry can offer. The engineering activities, which include the design and installation of specialised plant, cover a wide field and call for ability of a high order, both managerial and technical.

The salary offered will be consistent with these requirements. Applications will be treated in the strictest confidence and should be addressed to BOX A, c/o Graham and Gillies, Ltd., 37, Golden Square, London, W.1.

The advertiser's own staff are aware of this vacancy. E8583 A

APPLICATIONS ARE INVITED BY A PREMIER CONTINENTAL BEARING MANUFACTURER in the appointment of a GENERAL SALES MANAGER. Complete mobility is essential with a salary commensurate with experience and ability to produce results. Own employees informed. Apply Managing Director.—BOX No. E2095, "The Engineer." A

BBC requires ASSISTANT STRUCTURAL ENGINEER in London for work in connection with high masts and similar structures. Candidates should be qualified Civil or Structural Engineers with good experience of design and construction of reinforced concrete and steelwork structures and of contract procedure and administration. They should be physically fit and able to undertake inspection work at height. Age preferably 30/45 years. The work involves travelling. Salary in scale of £970 rising by annual increments to £1340 p.a. Promotion prospects.—Application forms from Engineering Recruitment Officer, Broadcasting House, London, W.1, quoting ref. EX.189 Eng. E8597 A

BOILER AND FABRICATING DEPARTMENT MANAGER required for old-established Company in the East Midlands. Age 35-45. Must have served apprenticeship to the trade and preference will be given to candidates with experience of fusion welded boiler and pressure vessel construction to Class I standard. A large-scale modernisation programme is in being and the post offers scope to a man with drive and initiative who is able to handle new projects. The ability to control labour and maintain sound industrial relations is essential. Pension Scheme.—Apply stating age, qualifications, experience and salary desired to BOX No. E8599, "The Engineer." A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy for a MECHANICAL ENGINEER at its head office in London for duties concerned with technical aspects of industrial lubrication. Applicants, aged 30–40, should possess a University Degree or A.M.I.Mech.E., and have had experience of metal cutting and forming and general industrial lubrication. Salary, according to age, qualifications and experience. Non-contributory pension fund. Assisted house purchase scheme. Removal expenses and settling-in allowance payable in certain cases. Luncheon club.—Write, giving full particulars, quoting reference H.4511, to BOX 5835, c/o 191, Gresham House, E.C.2. E8585 A

CHIEF DRAUGHTSMAN required for small but active D.O. engaged on special industrial heating equipment—Ovens, Furnaces, Impregnating Plants, &c. Good prospects for capable man with sound engineering background and experience of fabrication and sheet metal construction. Housing available. —Application in confidence, stating age, experience, salary level to Technical Manager, Barlow-Whitney, Ltd., Bletchley, Bucks. E8611 A

CHIEF MECHANICAL ENGINEER. Large Opencast Mining Company require in Sierra Leone professionally qualified ENGINEER with experience in responsible charge. Duties include responsibility for mechanical and electrical work connected with extensive earthmoving machinery, belt conveyors, power houses, workshops, &c. Age not under 35. Commencing salary £3000 per annum plus 5 per cent. bonus plus, for married man, passage or separation allowance of £10 per month and £5 per month for each child. 15 month tours followed by liberal leave on full salary in U.K. Return passage paid. Free furnished quarters and medical attention. Contributory Pension Scheme with retirement at age 55. Life Assurance and Dependents Income Schemes. —Write giving full details experience stating age, married or single, to SIERRA LEONE DEVELOPMENT COMPANY, LTD., Dept. C6, City-Gate House, Finsbury Square, E.C.2. E8606 A

CONTRACTS ENGINEER required in West End of London. A.M.I.Mech.E. or equivalent. Able take responsibility for preparation of large composite tenders and office supervision of resulting contracts. Some electrical knowledge desirable. Experience in the rubber/plastics or associated manufacturing industries an advantage but not essential. Excellent opportunity for right man. Applications, with full details and indication of salary required, will be treated in absolute confidence. Apply.—BOX No. E2082, "The Engineer." A

DESIGNER/DRAUGHTSMEN—preferably experienced in design of jib cranes, &c. The positions offered are due to expansion of the firm's activities ; would be permanent, progressive, and would carry salaries commensurate with experience. Pension scheme. Five-day week.—Apply : Chief Draughtsman, Clyde Crane and Engineering Company, Mossend, Bellshill. E8575 A

SITUATIONS VACANT

DEPARTMENTAL WORKS MANAGER

required by medium-sized Engineering Works situated in South Yorkshire.

Essential qualifications :

Engineering apprenticeship.

Technical training to at least O.N.C. level in Engineering and/or Metallurgy.

Several years' experience in Supervisory position in Medium/Heavy Engineering.

Age limits 35–45 years.

Starting salary not less than £1200 p.a. according to experience (Pension Scheme in operation).

Applications to Method Engineering (Management Consultants), Ltd., 39, St. Michael's Lane, Leeds, 6, quoting Ref. 2384.

E2097 A

DESIGN DRAUGHTSMAN : A senior man with good engineering experience is required for a Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential. The work entails handling projects from the drawing-board through to construction and running in for production. Salary will be from £850 p.a., plus lunches and an annual bonus, according to age, experience, &c.—Write, giving full details of age, qualifications, experience, &c., to BOX No. E8607, "The Engineer." A

DESIGNER-DRAUGHTSMEN THE GENERAL ELECTRIC COMPANY, LIMITED,

Have vacancies for experienced men in their General Engineering Division at Erith, Kent.

Applicants must have served an engineering apprenticeship and be technically qualified to H.N.C. standard or similar, although consideration will be given to those having the O.N.C.

Preference will be given to applicants having experience in one of the following fields :—

1. Layout and design of material handling plants, including conveyors, trippers, feeders, chutes, bins, buildings, foundations, &c. In this respect a good structural steelwork man would be considered.
2. Layout and design of coal preparation plants.
3. Layout and design of metalliferous mining plants or gravel plants, including crushers, screens, elevators, chutes, launders, pipework, supporting structures, foundations, &c.
4. Layout and design of mine winding engines and ancillary equipment.

Men having a good all-round heavy mechanical engineering experience, or from allied industries, such as the iron and steel industries, will also be considered.

The positions offered are permanent and a good salary will be offered to successful applicants. There is a superannuation scheme in operation ; also good canteen and welfare facilities.

Application should be made in writing, giving full particulars of experience, qualifications and age, to the Personnel Manager (G.E.D.), The General Electric Company, Limited, Erith, Kent.

E8582 A

DRAUGHTSMEN. Vacancies exist in the Southampton Drawing Office of Vickers-Armstrongs (Engineers), Ltd., engaged on machinery installation work in connection with the application of nuclear power for marine purposes. Working conditions are excellent and the work is interesting and offers scope for initiative. Applicants should have served a recognised apprenticeship and should have had Mechanical or Marine Steam Engineering experience. —Applications should be made in writing to the Manager, Vickers-Armstrongs (Engineers), Ltd., Oak Yard, Hazel Road, Itchen, Southampton. E8608 A

ENGINEER

Graduate or equivalent, required for development work in the scouring of textiles and textile fibres with organic solvents. Experience essential in the design and operation of textile finishing machinery. Starting salary £1300–£1550 p.a. according to experience. Pension Fund and Profit-Sharing Scheme.—Apply BOX No. E8602, "The Engineer."

A

EXECUTIVE APPOINTMENTS LIMITED

acting for

a leading manufacturer of pre-cast concrete products located in N.E. England with 200 employees and preparations in hand for further expansion seek a

GENERAL WORKS MANAGER

to take over complete responsibility for production. This is a new appointment offering a salary of not less than £2000 plus share of profits, considerable scope for initiative and the prospect of a seat on the Board.

This post will interest mechanical or production engineers aged 33–44 with public or grammar school education and qualifications to approximately A.I.Mech.E. standard who have recently been successful in a senior works management position in a progressive medium-sized engineering concern. Previous experience in concrete production or founding and special knowledge of modern production control techniques and/or work study would be an asset.

Write briefly knowing that identities will not be divulged without permission.

The Managing Director (WT.92),
EXECUTIVE APPOINTMENTS LIMITED,
67, Wigmore Street, London, W.1.

E8613 A

Classified Advts. continued on page 140

SITUATIONS VACANT

JAMES A. JOBLING AND CO., LTD.
manufacturers of
" PYREX "
brand glassware
have a vacancy for a
DIVISIONAL MANAGER
responsible to the Executive Director-Production for the administration and co-ordination of all activities of the Engineering Departments providing a service to the Manufacturing and allied divisions.
Applications are invited from men aged 40 and over, possessing a University Degree or equivalent, who have held a senior managerial position for at least five years, preferably in a processing industry, and who have in consequence a wide knowledge of modern management and engineering techniques.
The position is permanent and pensionable.
Write, in strict confidence, stating age, experience and salary required to the Personnel Manager, Wear Glass Works, Sunderland.

E8605 A

INSTRUMENTATION ENGINEER required, experienced in the design of major electro-pneumatic installations in connection with the Oil Refining and Chemical Industries. This position offers good prospects and a commencing salary up to £1500 per annum. Please reply, giving full details of experience and qualifications.—BOX No. E8554, " The Engineer." A

KODAK, LTD., have a vacancy for an OPERATIONAL EFFICIENCY ENGINEER to carry out daily performance checks on operation of Boiler Plant, Turbo Generators and Alternators and Refrigeration Plant. H.N.C. Electrical or Mechanical desirable and previous experience of Power Station practice essential. Free Pension and Sickness Benefit plans in operation.—Please write Men's Personnel Department, Kodak, Ltd., Harrow, Middlesex. E8638 A

MOBIL OIL COMPANY, LIMITED
invites applications for the following appointments in the Technical Services Department :
(1) HEATING/COMBUSTION ENGINEER with good experience of industrial furnaces for the position of Field Engineer. The successful applicant will be on the headquarters (Westminster) staff of the Department and will be responsible for the field engineering service supporting the marketing of fuel oils. Minimum academic qualifications are a degree (or equivalent) in engineering but good technical experience is of utmost importance. Ref. FE 1.
(2) HEATING/COMBUSTION ENGINEER with good experience of industrial furnaces and petroleum fuels. The successful applicant will be on the staff of the Technical Services Laboratory at Coryton, Essex, but will be expected to spend considerable time away on field work. Academic requirement is a degree (or equivalent) in Engineering but knowledge of fuel products and industrial experience is of utmost importance. Ref. FE 2.
(3) LABORATORY TECHNICIAN with O.N.C. (or equivalent) in Engineering and at least two years' industrial experience preferably concerned with combustion. The successful applicant will be on the staff of Technical Services Laboratory at Coryton, Essex, but will be expected to spend considerable time away on field work. Ref FE 3.
All of the above appointments are progressive and employment with the Company offers generous employee benefits including Pension and Life Assurance, sports and social club facilities, &c. In the case of (2) and (3), housing assistance may be given if necessary.
Applications giving full details should be sent to :—
Employee Relations Department,
MOBIL OIL COMPANY, LTD.,
Caxton House, London, S.W.1,
quoting Ref. TS/9407 E/1/2/3 as applicable.

E8596 A

POWER RECTIFIER DESIGN
A large manufacturing firm in the Midlands requires electrical engineers to assist in development and design of high-power rectifier equipments, in a rapidly growing Department handling rectifiers of both mercury arc and semiconductor types for applications of all kinds. Work offers scope for wide experience and interest, with good salary and prospects. Previous rectifier experience not necessary, but a degree or equivalent, and some practical experience, are desirable. Good residential district with excellent educational facilities and ample housing available.—Apply with full particulars to BOX No. E8526, " The Engineer."
A

PRODUCTION ENGINEER.—An engineering company in Outer West London is seeking a Senior Executive with a good general engineering background. Knowledge of heavy press and tool work with experience of work study and cost investigation. Only men with considerable experience should apply, and preference will be given to an applicant who is holding a similar post at present. Write full particulars, stating age and salary required, quoting reference P.E.—BOX No. E8617, " The Engineer." A

QUANTITY SURVEYING ASSISTANT required by professional firm. General experience in Civil Engineering side advantageous. Age range 28–40. Salary according to experience.—Please indicate previous employers, nature of employment and any qualifications to BOX No. E8604, " The Engineer." A

SENIOR DESIGN ENGINEER
required with a Degree of Membership or Corporate Institution in Civil or Mechanical Engineering with sound engineering background.
In this post a lively and enthusiastic approach to engineering problems is desired.
Applications stating age, education, experience and salary required to MOTHERWELL BRIDGE AND ENGINEERING COMPANY, LTD., P.O. Box 4, Motherwell. E8625 A

SENIOR ELECTRICAL DESIGN ENGINEER required for a firm manufacturing a large range of Industrial Trucks. Applicants must be capable of taking charge of Electrical Design and Development sections and will be responsible to the Chief Designer for design and/or choice of all electrical apparatus required for traction and equipment drives. Only applicants with experience of similar work will be considered.—Applications marked " Confidential " to BOX No. E8580, " The Engineer." A

SENIOR ESTIMATOR, experienced in all classes of Cast Iron and Steel pipework schemes, required by company specialising on contract work for the Chemical, Oil and allied trades. Salary commensurate with the position.—Reply to General Manager, BOX No. E2089, " The Engineer." A

SUPERINTENDENT OF WAY AND WORKS required for maintenance of Railway way and works and for supervision of new works with British Company operating Railway and Harbour in Goa, Portuguese India. Salary scale £1600 by £100 to £2400 and Provident Fund. Expatriation Allowance of £240 per annum. Education Allowance. Car provided. Free quarters. A knowledge of the Portuguese language would be desirable.—Apply Sir Bruce White, Wolfe Barry and Partners, 1, Lygon Place, Grosvenor Gardens, London, S.W.1. Tel. : SLOane 3433. E8600 A

TECHNICAL ASSISTANTS required by pipework contracting company for permanent head office appointments—North West area. Successful applicants will be required to handle contracts through the planning and engineering phases to completion. The duties will also include taking off quantities from pipework drawings and assisting in estimating processes. Good all-round pipework knowledge with drawing office experience is essential. —Reply to General Manager, BOX No. E2088, " The Engineer." A

TECHNICAL AUTHOR. Vickers-Armstrongs (Engineers), Ltd., Southampton, have a vacancy for a TECHNICAL WRITER, conversant with the preparation of instruction books in connection with Marine Engineering. The project includes the very latest developments in Naval practice and is of great interest. Working conditions are excellent.—Applications should be made in writing to the Manager, Vickers-Armstrongs (Engineers), Ltd., Oak Yard, Hazel Road, Itchen, Southampton. E8609 A

TECHNICAL WRITER
required by Company now extending its range of nucleonic instruments. Knowledge of electronics desirable. Salary in accordance with experience. Opportunity of advancement.
Apply : Personnel Officer,
ISOTOPE DEVELOPMENTS, LTD.,
Beenham Grange,
Aldermaston,
Nr. Reading, Berks.

E8637 A

THE BAHRAIN PETROLEUM COMPANY, LIMITED
STORES DEPARTMENT
ASSISTANT WAREHOUSE SUPERVISORS

Applications are invited for these positions from men of secondary education, 28 to 35 years of age, who have had a career in storekeeping, reaching supervisory positions involving the control of 30 or 40 men and up to 20,000 stock items, mostly of a heavy nature connected with engineering or heavy process plant, previous experience with refinery stores being an advantage. Duties cover receipt checking, labelling, stacking or binning, protecting and issue.
The salary would be in accordance with qualifications and experience, in addition to which free air-conditioned accommodation and an adequate living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided, with participation in pension and provident fund schemes.
Apply in writing, quoting " STR " and with full particulars of experience, &c., to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1.

E8590 A

THE INSTITUTION OF STRUCTURAL ENGINEERS
APPOINTMENT OF DEPUTY SECRETARY

Applications are invited for the appointment of DEPUTY SECRETARY of the Institution of Structural Engineers at their Headquarters in London, with a view to eventual appointment as Secretary.
Applicants should preferably be corporate members of a Chartered Engineering Institution, have appropriate administrative experience and be between the age of 35 and 50.
The commencing salary will be from £1800 to £2000 per annum according to experience.
The closing date for the receipt of applications is the 24th October, 1958.
For further details apply to the Secretary of the Institution, 11, Upper Belgrave Street, London, S.W.1, the envelope to be marked " Deputy Secretary."

E8451 A

THE STEEL, PEECH & TOZER BRANCH OF THE UNITED STEEL COMPANIES, LTD., invites applications for the post of ASSISTANT ROLLING MILLS SUPERINTENDENT in a works containing Cogging, Billet, Slab, Bar, and Hot and Cold Strip Mills. A metallurgical or engineering training followed by rolling mill management experience is essential, and a degree qualification will be an advantage. Salary may exceed £1500 per annum according to experience.—Full details of education and experience should be provided in writing to The Secretary, Steel, Peech & Tozer, The Ickles, Rotherham. E8635 A

THE STEEL, PEECH & TOZER BRANCH OF THE UNITED STEEL COMPANIES, LTD., invites applications for the position of NEW CONSTRUCTION ENGINEER to take complete charge, under the Chief Engineer, of all extension work. Age limits 30–45. Essential qualifications are a sound practical training followed by experience in Civil, Structural, and Mechanical Engineering associated with the installation of plant, machinery, buildings, services, &c., for the heavy steel industry. A degree or professional qualification is desirable. The position is not a temporary one. Salary may be £1500 per annum according to experience.—Full details of education and experience should be provided in writing to The Secretary, Steel, Peech & Tozer, The Ickles, Rotherham. E8636 A

THE UNITED GLASS BOTTLE MANUFACTURERS, LTD. are one of the largest glass container manufacturers in Europe, and have factories in various parts of the country.
At St. Helens, Lancashire, there are vacancies for :—
DESIGN ENGINEER DRAUGHTSMEN, Senior and Junior, with experience in design and detail design of Medium Heavy Special Purpose Machines, and devices for the manufacture of glass containers and special ware.
PLANT LAYOUT DRAUGHTSMEN, Senior, for Works Engineers Office. Estimating experience essential.
These positions offer scope and good prospects for men with imagination and the ability to get things done.
An excellent Superannuation and Life Assurance Scheme is in operation.
Applications giving age and details of qualifications and experience should be sent to the Personnel Officer, Sherdley Works, St. Helens.

E8572 A

WEST MIDDLESEX FIRM require immediately a competent ENGINEERING DRAUGHTSMAN, fully experienced in design of electro-mechanical devices.—BOX No. E136, " The Engineer." A

WHESSOE LIMITED, DARLINGTON
Engineers to the oil, gas, chemical, and nuclear power industries
Require a young graduate MECHANICAL ENGINEER, preferably with knowledge of Metallurgy, to join their Welding Department to work on the development of welding materials, processes and techniques used in the design and manufacture of the Company's products.
Apply to the Staff Officer, Whessoe, Ltd., Darlington, within seven days, mentioning " The Engineer."

E8598 A

WORKS MANAGER required for West Yorkshire factory by a firm of Mechanical and Electrical Engineers specialising in light engineering. A sound knowledge of press, capstan and welding work is essential. The man appointed must be a good disciplinarian with a knowledge of production control methods. House available. Applications, stating age, experience and salary required.—BOX No. E2087, " The Engineer." A

YOUNG ENGINEER required by a Company specialising in non-ferrous metals, for handling projects from the design stage on the drawing board, following through to machine construction and running in on the shop floor. A sound practical training and knowledge of engineering services is essential. Experience of non-ferrous metals would be an advantage. Candidates, who should be between 23–30, should write, giving full details of experience, qualifications, age, &c.—BOX No. E8403, " The Engineer." A

YOUNG ENGINEER required for technical work in large light engineering firm in Mid-Sussex. Qualifications should include H.N.C. (Mechanical) or equivalent, and practical engineering training. Working conditions are good, there are excellent prospects and salary will be according to experience. Please apply, giving full details of training, practical experience, previous and present positions and age.—BOX No. E8586, " The Engineer." A

£2,000,000. We have been spending this sum annually on new plant and equipment, and our budget is now still higher. Since we design and erect our own plant, we must recruit ENGINEERS and DRAUGHTSMEN of all types to meet this programme. We pay good salaries, and the Headquarters are pleasantly situated near London.—Apply briefly to BOX No. E8594, " The Engineer," quoting Ref. P.E.D. 1. A

PILKINGTON BROTHERS LIMITED

TECHNICAL DEVELOPMENT DEPARTMENT

(A). 4 SHIFT MANAGERS
to be responsible for the day-to-day running of an important experimental unit involving all aspects of glass manufacture ; in close liaison with Research and Production Departments. A good honours degree in mechanical or chemical engineering or physics is necessary and appropriate experience desirable.

(B.) 4 DEVELOPMENT PHYSICISTS
capable of making a practical contribution to the work of the experimental team. A good science degree is required.

(C). 2 ASSISTANT DEVELOPMENT PHYSICISTS
to assist in process development work. Higher National Certificate required.

Apply, stating age, qualifications, experience, and present salary, to Personnel Officer (Graduate Recruitment), Pilkington Brothers Ltd., St. Helens, Lancashire.

E8588 A

ASSISTANT DESIGN ENGINEER

required by Centrifugal Pump Manufacturers in the North Midlands.

Applicants, aged 30 to 40, must have comprehensive experience in this field, with good knowledge of Hydro-Dynamics, and Technical Education up to A.M.I.Mech. E. Standard or equivalent.

The successful candidate must be capable of advising on pump applications, and be able to handle the design problems connected with specification contracts and new development work. The appointment is progressive, and interviews can be arranged for weekends, travelling expenses being paid.

Canteen facilities and Staff Pension Scheme.

Please reply, giving full details of age, (experience, and salary required to BOX No. E8592, " The Engineer."

A

BICC

British Insulated Callender's Construction Co., Ltd., carrying out important Railway Electrification contracts in connection with the Transport Commission's railway modernisation programme, require additional Design Staff at their Traction Department Headquarters, Kirkby, Nr. Liverpool, namely :

STRUCTURAL ENGINEERS
DESIGNERS
DRAUGHTSMEN

The work is varied and interesting, involving the design of foundations and structures carrying overhead wiring. Appointments are intended for the Company's permanent staff ; prospects are good and salary will be generously assessed according to age, qualifications and experience.
Applications should be addressed to :
The Works Personnel Officer,
Ref. C.355,
B.I.C.C., Ltd.,
Prescot, Lancs.

E138 A

SENIOR INSTRUMENTATION ENGINEER

A major Oil Company requires, for an important oil pipeline project in India, an engineer capable of undertaking the design in London and later the installation and commissioning in the field of system of instrumentation appropriate to the remote control of large pumping stations by a radio telemeter system. Oil measurement by meters will be a feature of the scheme.

Candidates should preferably have held responsibility for the execution of similar projects and salary will be commensurate with the importance of the post.

Mobility is an essential qualification.

Write stating age, technical qualifications and a brief description of career to BOX No. TE.691, c/o 191, Gresham House, E.C.2.

E8518 A

PILKINGTON BROTHERS LIMITED

DONCASTER WORKS

(A). DEVELOPMENT PHYSICIST

(B). DEVELOPMENT ENGINEER

Aged 22-30, with good honours degree, to produce and develop original lines of thought in flat glass making techniques. Scope for initiative and responsibility ; opportunity for early promotion.

Apply, stating age, qualifications, experience, and present salary, to Personnel Officer (Graduate Recruitment), Pilkington Brothers Ltd., St. Helens, Lancashire.

Interviews at Doncaster.

E8587 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

CHIEF DEVELOPMENT ENGINEER

for a young public company, with a progressive management, which has shown a remarkable achievement in its rate of expansion over the past few years. The company, with its main works in the Midlands, employs approximately 2,000 and is engaged in the development, design and mass production of light electro-mechanical mechanisms.

This is a new appointment to co-ordinate the efforts of the design teams with a view to maintaining their lead in this field and also to achieve further expansion plans laid down by the board. Responsibility will be to the Managing Director.

Candidates must possess a degree or other professional qualification, preferably in electrical engineering, and have extensive experience in the design of small intricate mechanisms under mass production methods, and a sound knowledge of electronics.

Preferred age about 40. Salary will be dependent on experience, but should not be less than £2,500.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1212, to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

MSL have been retained to advise on the appointment of a

TECHNICAL DIRECTOR

by an old established firm of boiler makers and engineers in Scotland. The company employs about 650 people, and is situated in pleasant country.

The Technical Director will be responsible to the Managing Director for all technical aspects of the company's activities in the fields of design, development, manufacture and sales.

Candidates must be B.Sc. (Eng.), A.M.I.Mech.E. or equivalent, with wide experience of steam raising practice, the design of boilers and pressure vessels. Public School education an advantage.

Preferred age : 40–50. Salary not under £3,000. Generous pension scheme. Assistance with moving and house purchase.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1254, to H. A. P. Disney.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E140 A

SITUATIONS VACANT

WELDING ENGINEER

required to control site welding of large oil storage tanks. The Welding Engineer will be responsible for advising on welding problems arising at any stage during site welding of tankage, and should have a thorough knowledge of welding codes, modern site welding techniques, and all forms of non-destructive testing. Position incorporates Non-Contributory Pension Scheme—Apply stating age, qualifications and previous experience to The Erection Manager, Wm. Neill & Son (St. Helens), Ltd., 38, Victoria Street, Westminster, London, S.W.1.

E8516 A

BUSINESS OPPORTUNITIES

A PRESS SHOP OR LIGHT ENGINEERING WORKS PROPRIETOR OR MANAGER who requires work or capital could, with advantage, study this announcement.

In our group, which has world-wide connections and a diversity of interests, there is room for a business which can, after any necessary re-equipping, take on quantity production of small precision pressings in difficult metals. Given the services of forward-looking personnel skilled in press tool design, maintenance and operation, and with adequate technical and metallurgical background, capital would present no problem. Moreover, this side of the business is assured of a substantial nucleus of orders covering deep drawn components of new products for which a rapidly expanding market is already established.

Initially, then, we require the services of a leader, not too far removed from the shop floor, who can, with our support, build up this unit as a major specialist supplier of the small press parts which others find it impossible or uneconomical to produce. Our plans are sufficiently flexible for us to start from scratch or to help the right man to build on to an existing business in which he already has an interest.

Even a highly skilled man well versed in the behaviour of the newer metals and alloys is likely to need all his ingenuity for many jobs which will come the way of this new organisation. Because this is a new venture we are using an accommodation address, but those in whom the challenge awakens a response and who have the will to keep abreast of developments, coupled with a dogged determination to see the job through, should send full details to The Chairman, BOX No. E8622, "The Engineer."

o

A PROGRESSIVE, old-established, medium-heavy engineering company in London, with an expansion problem, would be interested to ACQUIRE CONTROL of another good medium-heavy engineering concern located within easy reach of London (preferably south) and having an ample area of ground for further development. Replies treated in strict confidence.—BOX No. E2091, "The Engineer."

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PATENTS

THE PROPRIETOR of British Patent No. 590,586, entitled "IMPROVEMENTS IN HYDRAULIC POWER TRANSMISSION MEANS," offers same for licence or otherwise to ensure its practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, Chrysler Building, New York, 17, New York, U.S.A. E8507 H

THE PROPRIETORS of British Patent No. 723,272 for AN IMPROVED MACHINE COMPRISING A MOVABLE GRATING, OF THE DWIGHT-LLOYD TYPE, desire to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E8584 H

THE PROPRIETOR of British Patent No. 603,622 for "IMPROVEMENTS IN AND RELATING TO TRANSMISSION CABLES," desires to enter into negotiations with a firm or firms for the Sale of the Patent, or for the grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E8595 H

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E103 K

HIRE A £1500 CAMERA FOR ONLY £5. All other types of photographic equipment available.—B. Bennett and Sons, Ltd., 25/27, Oxford Street, London, W.1 (Telephone, GERrard 9953). Catalogue on request. E128 K

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

PRECISION ENGINEERS.—Personal service for prototypes, small quantity machined parts and equipments. Design and development undertaken. A.I.D. Approved.—Bowyer, Smyth and Partners, Ltd., Vineyard Walk, Clerkenwell, E.C.1 ('Phone, TERminus 5113/4). E112 MW

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Competitive Prices

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Surrey. E2094 S

MACHINERY Etc. WANTED

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham, 12. VIC. 1278, 1279, 1270, 0856. E104 F

UP TO 500 TONS STEEL BARS, 3in. to 6in., Rounds or Squares, minimum 4ft. lengths, Carbon 0·35/0·55 per cent.—Church and Bramhall, Ltd., Darlaston. E2092 F

FOR SALE

VALES PLANT REGISTER LIMITED
OFFER FOR IMMEDIATE SALE
CRANES

1 Ransome & Rapier 1-ton capacity Portable Crane, 20ft. lattice jib, Lister petrol engine, 4 pneumatics, Good condition. £275.
1 Neals 1-ton "D" type Mobile Crane, with 12ft. and 25ft. jibs, Ruston engine, on pneumatics. New 1951/52. Good condition.
1 Jones Super 3-ton Diesel Mobile Crane, 24ft. jib, Ruston engine, on pneumatics. In good condition. £950.
1 Neals NMS. 3-ton Diesel Mobile Crane, Ruston engine. New 1955. On pneumatics. In good condition.
1 Jones 4-ton LK.44 Mobile Crane, 24ft. or 40ft. jib, on pneumatics. New 1948. Thoroughly reconditioned.
2 Butters 5-ton Electric Single Motor Derrick Cranes, with 105ft./110ft. jibs. New 1948/49. Good condition.
1 Butters 5-ton Electric Single Motor Derrick Crane, with 90ft. jib, complete with set of bogies. New 1948. Good condition.
1 Butters 5-ton Hand Derrick Crane, 50ft. jib. New 1949. Fitted with hand slewing gear. £500.
1 Butters 7-ton, 2 motor, Electric Derrick Crane, 120ft. jib.
1 Anderson Grice 7-ton, 2 motor Electric Derrick Crane, 120ft. jib.
1 Henderson 10-ton Steam Derrick Crane, 120ft. jib. First used 1954. In very good condition.
1 Coles 12½-ton Fully Mobile Crane, with 45ft./80ft. jib. New 1950. £5500.

Further details, 14, Lower Grosvenor Place, London, S.W.1.
Telephone : VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

FOR IMMEDIATE SALE
ONE 25-TON GOLIATH CRANE
106ft. Span, 80ft. clear height under girders.
SPEEDS :

Main Hoist	25 tons—16ft per min.
Auxiliary Hoist	10 tons—40ft. per min.
Cross Traverse	200ft. per min.
Main Travel	200ft. per min.
Power Supply	400/440 volts, 3 phase, 50 cycles.

Approximate total weight of crane : 122 tons.
All weatherproof enclosures.
Can be seen under full working conditions by appointment with the Chief Plant Engineer. Ext. 291.

HERBERT MORRIS LIMITED,
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E8601 G

KEARNS OA HORIZONTAL BORER
with facing head and over-size table. War-time machine. M.D. 400/3/50.
H. BELL (MACHINE TOOLS), LTD.,
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LEEDS, 4.
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E105 G

FOR DISPOSAL, quantity of unused BALL AND ROLLER BEARINGS of Hoffman, S.K.F., R. and M., and Timken makes. These are obsolete, due to demolition of plant. Interested parties should write, Reference P/EB., Appleby-Frodingham Steel Company, Scunthorpe, Lincs, for details. Prepared to sell at very much below cost. E8509 G

FOR SALE

600

SPECIAL OFFERS
FOR PROMPT CLEARANCE
FROM MODERN POWER STATION

Three THOMPSON WATER-TUBE BOILERS, 26,000 lb. per hour evaporation, each 275 p.s.i.g., with chain grate stoker and accessories.
Two WEIR BOILER FEED PUMPS, 9in. by 12in. by 24in., 7200 g.p.h.
WEIR STAINLESS STEEL STEAM TURBINE-DRIVEN PUMP for boiler feeding, 2000 g.p.h., 200/265 p.s.i.g. Unused.
MISCELLANEOUS BOILER HOUSE PLANT AND EQUIPMENT
1500/2200kW. Condensing or Pass-out TURBO-ALTERNATOR SET by ALLEN/E.C.C., 275 p.s.i.g., 750 deg. F., gearbox, 6000/1000 r.p.m., 2750kVA. alternator, 400/440 volts, 3 phase, 50 cycles, 3600 amps., with control gear accessories, surface condenser and pumping set. Will consider sale of separate components.
"AULDS" REDUCING VALVE AND DE-SUPERHEATER, 275 down to 30 p.s.i.g., 12in. inlet, 18in. discharge.
COPPER BUS BAR, 4in. by ¼in., with two 2000 amp. isolators.
About 2500 yards P.I.L.C.A. POWER CABLE, including 4-core 0·3in. section, 3-core 0·15in. section, 3-core 0·3in. and 3-core 0·25in.
KENT STEAM FLOW METERING PANEL, 70,000/100,000 lb/hr.
170kVA., 134kW. ALTERNATOR by BRUSH, for "V" belt drive, 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m., with control gear.
200 h.p. Vertical, 3-cylinder, DIESEL ENGINE by CROSSLEY PCQ3, r.p.m. 500, with pressure blower, starting set and accessories.
12in. ALLEN CENTRIFUGAL PUMP, 3000 g.p.m., 40ft. head, 965 r.p.m.
63 h.p. SLIPRING MOTOR, 965 r.p.m., with starter.
14/16in. CENTRIFUGAL WATER PUMP by ALLEN, 20ft. head, 975 r.p.m.
56 h.p. SQUIRREL CAGE MOTOR, 975 r.p.m., with starter.
Two 4/6in. CENTRIFUGAL WATER PUMPS by WORTHINGTON SIMPSON, 833 g.p.m., 40ft. head, 1440 r.p.m.
Two 11 h.p. SQUIRREL CAGE MOTORS, 1440 r.p.m., with starters.
Two 4in. CENTRIFUGAL PUMPS by HARLAND, 666 g.p.m., 150ft. head, 2850 r.p.m.
Two 35 h.p. Totally Enclosed SQUIRREL CAGE MOTORS by BRUCE PEEBLES, 2850 r.p.m., with Ellison starters.
Two 2½in. CENTRIFUGAL PUMPING SETS with 3 h.p. motors.
SURFACE CONDENSER by ALLEN, designed to handle approximately 23,000 lb. of steam/hr., 28½in. vacuum with extraction pump, air ejector and water circulating pump.
ALTERNATOR, 3125kVA., 400/440 volts, 3 phase, 50 cycles, 1000 r.p.m.
HOWDEN 5ft. 6in. diam. Induced DRAUGHT FAN with 66 h.p. motor and water cooled bearings.
DISTRIBUTION SWITCHBOARD by E.E.C., seventeen panels with instruments and circuit breakers, nine at 400 amps., four at 1000 amps., and three at 600 amps. Will sell separately.
ELECTRICAL EQUIPMENT, 400/440 volts, 3 phase, 50 cycles.
OTHER MISCELLANEOUS EQUIPMENT, MATERIAL AND PIPING also available at bargain prices.
Apply : Mr. Booth,

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SONS AND CO. LTD.
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Glasgow, S.3.
Telephone : Langside 6131. E220 G

FOR SALE

10-ton Butters Hand Derrick Crane, 18ft. fixed radius.
3-ton Taylor Jumbo Hydraulic Crane, diesel driven.
5-ton Coles diesel-driven self-propelled Mobile Crane on pneumatics.
5-ton Morris Versatile diesel/elec. Mobile Crane on solid rubber tyres.
5-ton Smith Steam Loco. Crane, 4ft. 8½in. gauge, 35ft. jib, new 1949.
6-ton Rapier Super pet./elec. Mobile Crane on solid rubber tyres.
6-ton Rapier Standard pet./elec. Mobile Crane on solid rubber tyres.
Fordson Major diesel Tractor complete with Hornraulic shovel equipment.
¾ cu. yd. Rapier 410 diesel-driven Excavator with 4-purpose or dragline equipment.
¾ cu. yd. Rapier 423 diesel-driven Excavator with shovel or dragline equipment.
1 cu. yd. Rapier 440 diesel-driven Excavator with shovel or dragline equipment.

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E8453 G

FOR IMMEDIATE SALE.—One Heavy Duty Double-Ended Beam Bending and Straightening Machine by Smith Bros., capacity 16in., with Double Angle Cutters (not in use), motorised; One 18in. Slotting Machine by Butler, table 42in. diameter, admits 6ft., gearbox, motorised.—JOHN H. RIDDEL LTD., 62, Robertson Street, Glasgow, C.2. E2096 G

Classified Advts. continued on page 142

FOR SALE

FRED WATKINS (ENGINEERING), LTD.

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Broomwade 400, 300, 200 and 130 cu. ft.; all motorised; Reavell Rotary Blowers, 2000 c.f.m., 3–2 p.s.i.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib; 6-ton and 4-ton Coles Diesel-Electric; 3-ton Jones Super 40 (3); Neals 2-ton Diesel, 20ft. jibs (2); Derrick, 5-ton Butters Electric travelling type, 90ft. jib; 5-ton Wilson Electric, 70ft. jib; Steam Loco, 18-ton Brownhoist, 50ft. jib; 10-ton Coles, 40ft. jib; 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib; 5-ton Cowans Sheldon, 50ft. jib; 5-ton Grafton, 38ft. jib; E.O.T. 40-ton Adamson, 42ft. span; 20-ton Vaughan, 42ft. span (8); Goliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris; 5-ton Henderson, 24ft. 7½in. span, 1946; 5-ton King, 29ft. 3in. span; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.

LOCOS.—Fowler Diesel, 150 h.p. (2); Ruston Diesel, 80/88 h.p., new 1942; Hunslet 0–6–0, 18in. by 26in., new 1944; Bagnall 14in. by 22in., two oil fired, one coal; Peckett Steam, 7in. by 12in., 1941; also 3 miles track, 24in. gauge Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new; 60,000ft., 3in. black new; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 3800ft., 21in. seamless flanged; 500ft., 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¾in.; Robertson Straightening Rolls, 8ft. 6in. by ¾in.; Berry Bending Rolls, 7ft. by ¾in.; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table; Herbert 3ND Miller, 61in. by 15in. table; Pels Punch and Shears, ¾in. capacity; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

SLING ENGINEERING WORKS
COLEFORD, GLOS.
'Phone: Coleford 2271/2. E106 G

TWW

RAILS FOR SALE

100 TONS NEW SLIGHTLY DEFECTIVE B.H. RAILS, 95 lb. yard, chiefly 60ft.
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200 TONS SECONDHAND F.B. RAILS, about 60 lb. yard, 24ft., 27ft. and 30ft. chiefly.
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50 TONS MILD STEEL FLAT, 5in. by ¼in., new but Stock Rusty 15ft to 26ft. chiefly.
WARD'S ALSO HAVE LARGE STOCKS OF ALL CLASSES OF OTHER RAILWAY MATERIALS.

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E217 G

MULTIMAT NO. 3 CENTRELESS GRINDER

Capacity ¼in. to 7¼in. diameter; grinding wheel 24in. by 12in.; control wheel 14in. by 12in.; hydraulic wheel dresser; motor 37 h.p. Late type machine.

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E8627 G

ONE 57KW A.E.C. DIESEL GENERATOR, 480/240 volts. One 55kW A.E.C. Diesel Generator, 480 volts. Can be inspected in London.—Offers to Chief Engineer, Waterlow and Sons, Ltd., 32, Paul Street, E.C.2. Tel.: BIS 5400. E2093 G

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TAYLOR & CHALLEN No. 3 G.D.P. Geared, Double Sided, Double Action, Cam Action Drawing Press, arranged motor drive for 400/440/3/50, punch stroke approximately 7in., blankholder stroke approximately 3½in., tee slotted bed 18in. by 15½in., between uprights 20½in., weight approximately 51 cwt.

QUICKWORK No. 321 Motorised Rotary Shearing Machine, with circle cutting attachment, arranged motor drive for 400/440/3/50, capacity 14 S.W.G. mild steel, depth of shear throat 30in., cuts circles from 6in. to 60in. diameter, weight approximately 18 cwt.

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E207 G

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SALES BY AUCTION

		Main Location	*Auctioneers*
September 23–24	**Machine tools and miscellaneous stores,** including plant, etc.	M.O.S. Storage Depot, Harrogate Road, **Yeadon, Leeds.**	DACRE, SON & HARTLEY (Dept. L), Station Road, Otley, Yorks. (Tel.: 3321.)
September 25–26	**Miscellaneous stores,** including :—	M.O.S. Storage Depot, **Rotherwas, Hereford.**	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
	Bedford, Morris, Austin, Hillman, A.E.C., Dennis, Mack, Landrover, Albion and Diamond "T" petrol and diesel engines, Matchless M/C engines and gearboxes, cylinder blocks, radiators, front and rear axles, differential units, gear boxes, transmissions and other M/T spares, vehicle equipment, sparking plugs, household furniture and equipment, 1000 binoculars, electric cable, drop tank, trollies and spares, building materials, electric furnaces, welding units, etc.		
September 30 October 1	**Machine tools and miscellaneous stores,** including :—	M.O.S. Storage Depot, **Ruddington, Notts.**	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate Nottingham. (Tel.: 47271.)
	Lathes, milling and cutting machines, surface, internal and external grinders, universal woodworking machine, moulding and planing machines, electric welders, hardness testers, presses, engravers, textiles, canvas covers, socks, gloves, greatcoats, oversuits, M/C coats and goggles, rubber thigh boots, vehicle washing plants, jacks, battery charging sets, M/T spares, "Pul-lifts," electric and hand stackers, "Crabtree" rotary printing presses, tank engines, petrol cans, etc.		
October 3	**Miscellaneous stores,** including machine tools, furniture, canvas, etc.	Command Ordnance Depot, **Coypool, Marsh Mills, Plymouth.** (Sale at Kinterbury House.)	WOOLLAND, SON & MANICO (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)
October 7	**Machine tools and miscellaneous stores,** including textiles, etc.	M.O.S. Storage Depot, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
October 14–15	**Vehicles and miscellaneous stores**	Central Ordnance Depot, **Bicester, Oxon.**	MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
October 21–23	**Vehicles and miscellaneous stores**	M.O.S. Storage Depot, Royal Arsenal, **Woolwich, S.E.18**	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)

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Broaching and boring machines, drills, surface and thread grinders, centre and turret lathes, milling machines, slotters, etc., located at Ruddington, Nottingham.
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(a) *Catalogues* for the above auction sales, 1s. 0d. each (P.O.s only), obtainable *only* from the auctioneers shown above.

(b) Applications for *Tender forms* should be made to the Ministry of Supply, Directorate of Disposals, First Avenue House, High Holborn, London, W.C.1.

E118 J

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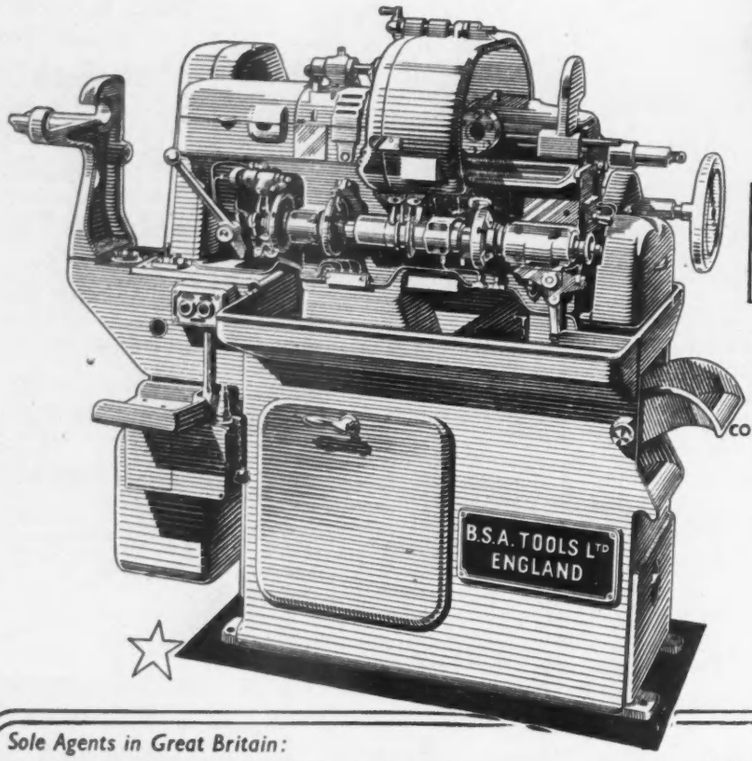

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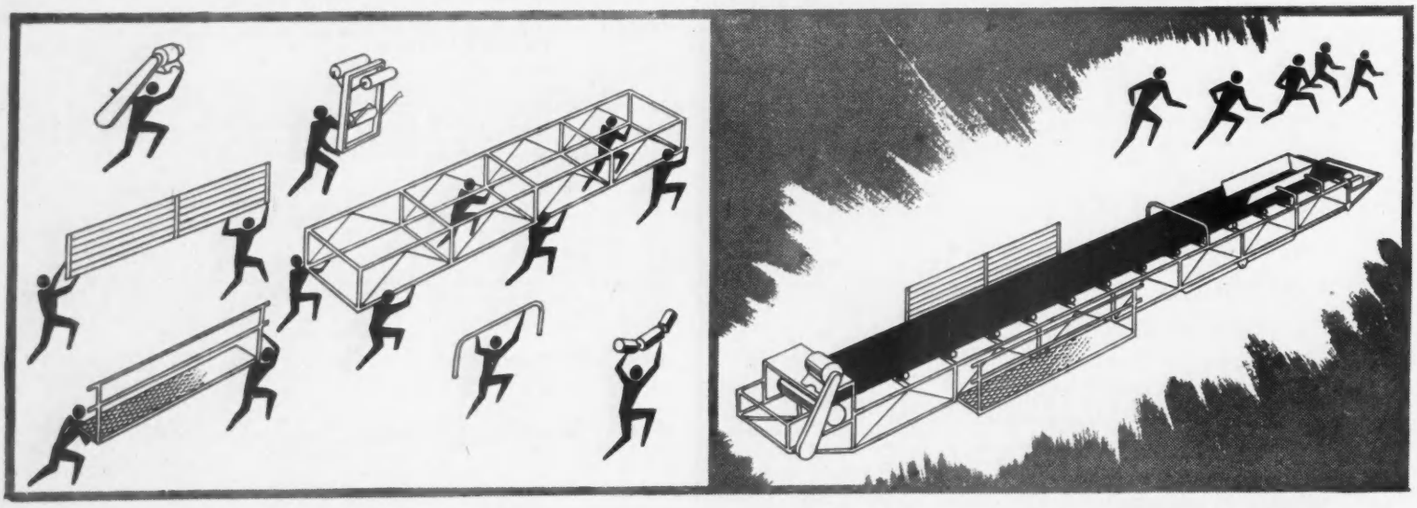

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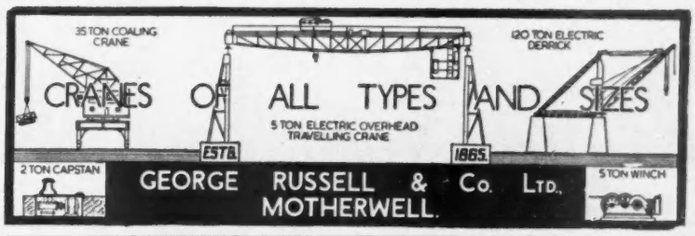
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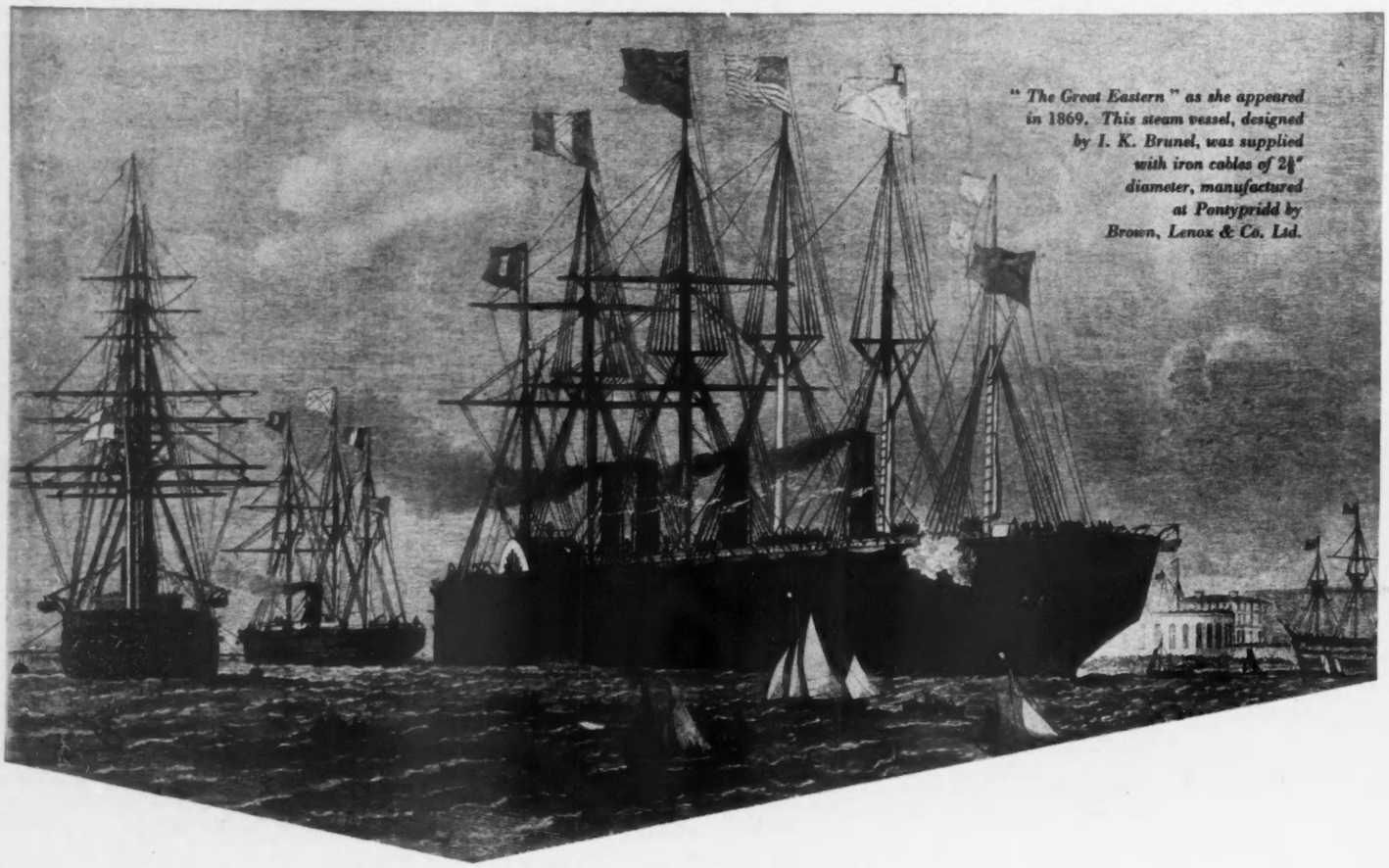

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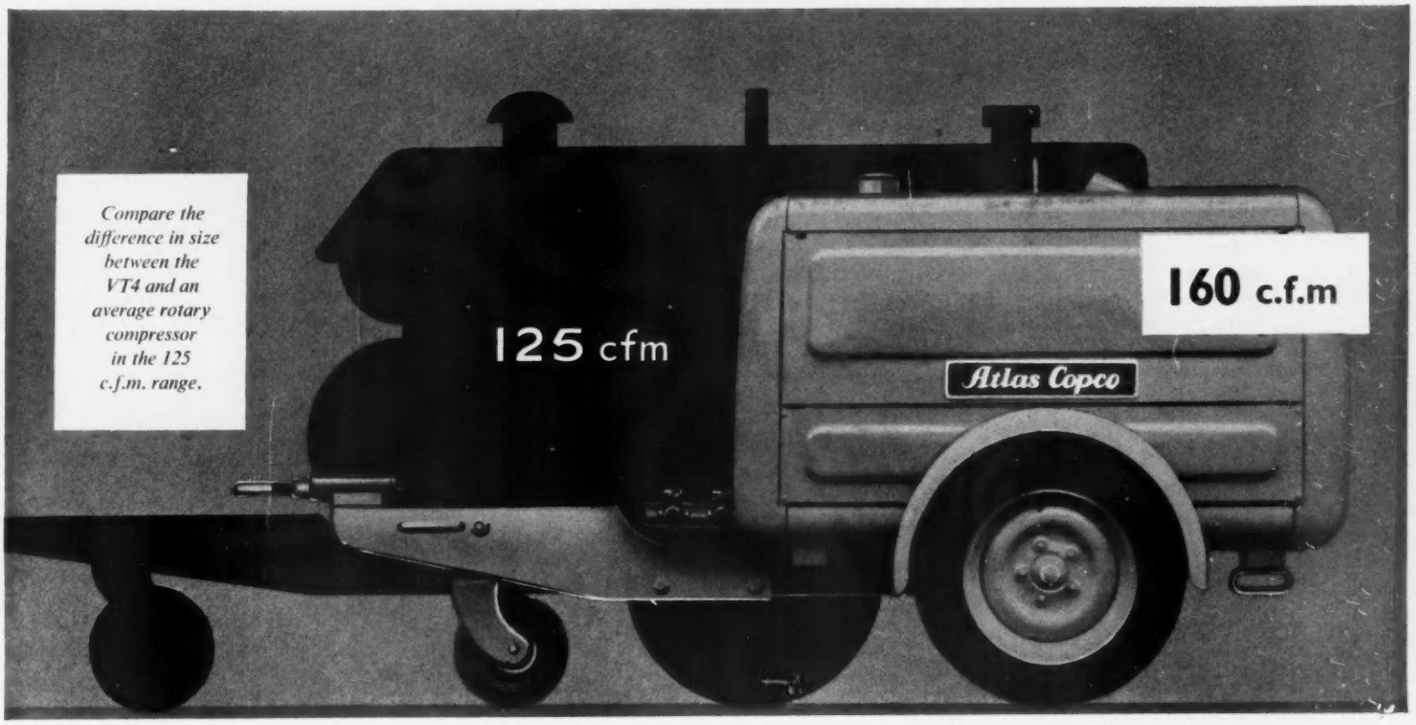
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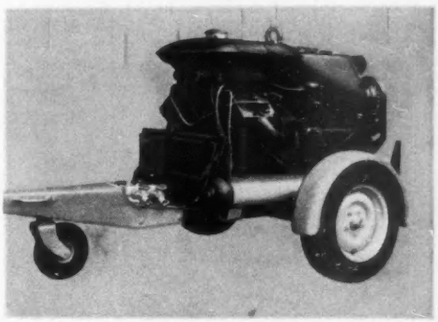

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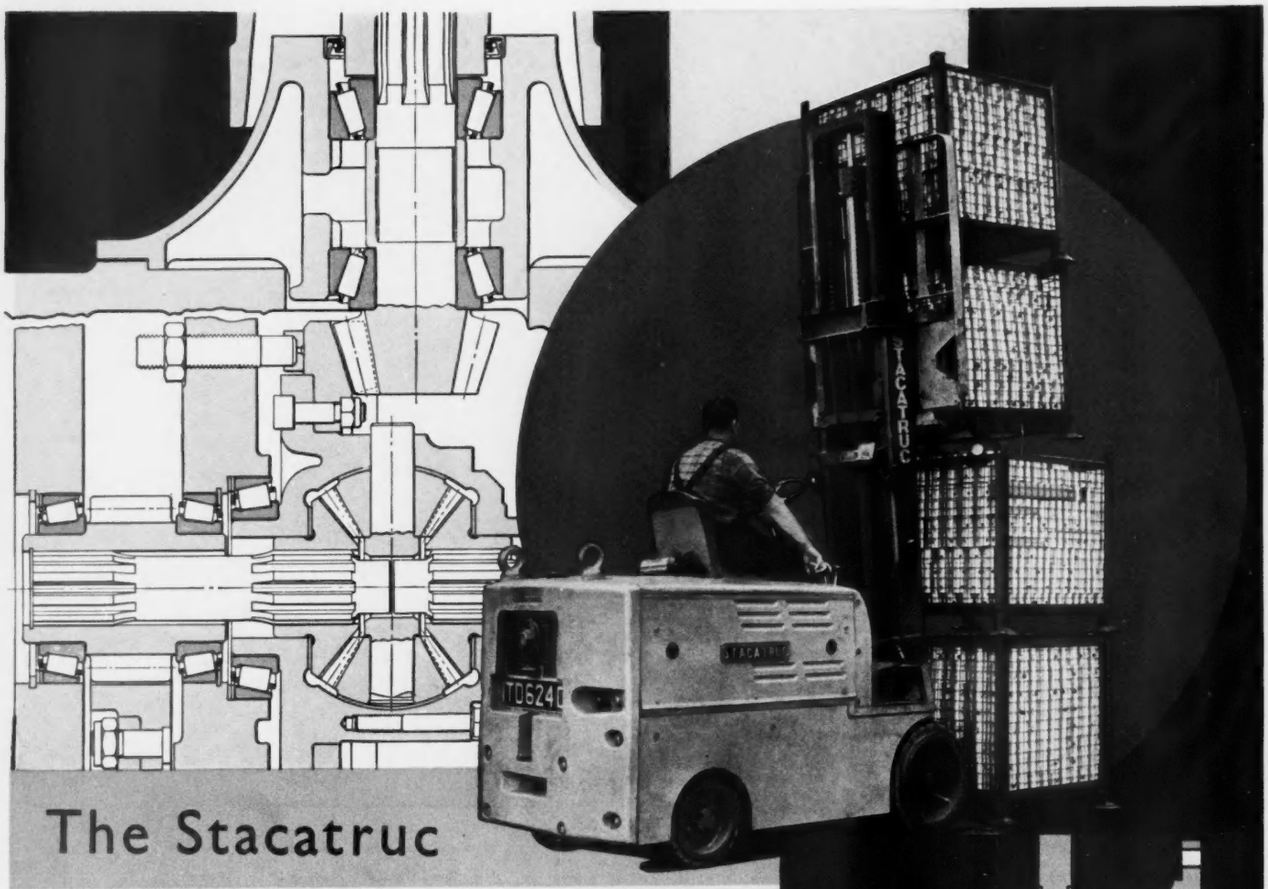

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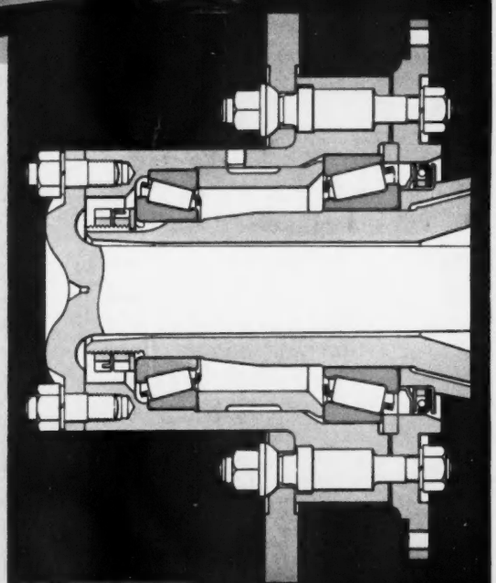

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